NORTH DAKOTA GAME AND FISH DEPARTMENT

Final Report

Wetland Occupancy by Shorebirds in Wind Energy Developments in the Prairie Pothole Region of North Dakota

Project T2-2-R

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Probability of Presence and Detection of Shorebirds on Wetland Basins in Wind-Developed and Reference Sites in the Prairie Pothole Region

Final Report to the North Dakota Game and Fish Department Habitat Division

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Abstract

To address whether recent wind development has had a negative effect on wetland use by shorebirds, we conducted a three-year study to estimate wetland-level probability of presence and detection of marbled godwit (*Limosa fedoa*), willet (*Tringa semipalmata*), and Wilson's phalarope (*Phalaropus tricolor*) on sites with and without wind development in the Prairie Pothole Region (PPR) of North and South Dakota. Each spring during 2008–2010 we surveyed wetland basins in two wind projects and in two nearby reference sites that lacked wind development. We surveyed 10,470 wetland basins on the four study sites during 2008–2010. Two surveys were conducted: the first in early May and the second in early June. At least one of the study species was present on 453 (or about 4%) of the surveyed wetlands. For the three study species combined, basin-level probability of presence and detection varied among sites; was lower in 2009 and 2010 than in 2008; decreased with the amount of emergent cover on the basin; was lower in the second survey; was lower on basins near roadsides; decreased with basin wet area; increased with the square-root of basin wet area; and increased with the product of basin wet area and the square root of basin wet area. Our data indicated that wind development was probably not causing substantial reductions in shorebird occupancy on our study sites. Apparent presence of shorebirds was low (< 0.05) for all sites in all years, and 95% confidence intervals of mean estimates of the probability of presence and detection overlapped substantially among sites. Nonetheless, we caution that the low apparent densities of shorebirds present a challenge to researchers and managers seeking to understand potential effects of wind development on shorebird populations, and we suggest that strong conclusions will most likely continue to be elusive without a substantial research and monitoring effort dedicated to these species.

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Introduction

Concern about dependence on foreign sources of energy and the impact of global climate change has resulted in increased interest in development of domestic, renewable, lower-emission energy sources (Barker et al. 2007). Wind energy has many desirable characteristics, but wind energy development can adversely affect wildlife populations (Kuvlesky et al. 2007). The Prairie Pothole Region (PPR) of the north-central United States is an area with high wind energy potential where wind energy development has recently increased. Because of its abundant glaciated wetlands and expansive native grasslands, the PPR is also an important breeding and migration area for many of the continent's grassland-nesting shorebirds (Skagen and Thompson 2000).

Marbled godwit (*Limosa fedoa*), willet (*Tringa semipalmata*), and Wilson's phalarope (*Phalaropus tricolor*) are three of the most common breeding shorebird species in the PPR. These species are classed as species of conservation concern (Brown 2000, Skagen and Thompson 2000) and conservation of their breeding habitat has been identified as a priority by the Prairie Pothole Joint Venture (Ringelman 2005). Habitat management for these species is focused on perpetual protection of intact grasslands and wetlands within the PPR. Perpetual protection is usually achieved through a United States Fish and Wildlife Service (FWS) conservation easement. A critical assumption of this program is that undisturbed grassland and wetland habitat is essential to the reproductive success of these birds and that activities such as conversion of grassland to cropland tend to be associated with reduced breeding success. This assumption is supported by the current scientific understanding of shorebird breeding ecology (Gratto-Trevor 2000, Lowther et al. 2001, Stephens 2006).

The most pressing current threat to populations of birds that breed in the PPR is loss and degradation of grassland and wetland habitat through conversion to cropland (Stephens et al. 2008). Conversion to cropland is associated with negative effects for waterfowl, shorebird, songbird, and raptor populations (Stephens et al. 2005, Stephens 2006). Therefore, protection of grassland and wetland habitat is a logical broad-scale conservation strategy. The value of grassland and wetland habitat could, however, be diminished by wind energy development. Conflicts between wind energy development and shorebird populations could arise as a result of many factors. Disturbance and avoidance caused by increased activity in wind projects; direct mortality caused by towers, turbines, and transmission lines; and reduced breeding success caused by changes in predation pressures are some of the outcomes that have been observed for other bird species (Winkelman 1990, Petersen and Poulson 1991, Usgaard et al. 1997, Leddy et al. 1999). Any of these potential effects are worthy of investigation. However, shorebird populations can be challenging to study because these species occur at low densities and can be difficult-to-detect (Neal Niemuth et al., USFWS HAPET, Bismarck, ND, unpublished manuscript). Rather than immediately trying to estimate and understand changes in vital rates of shorebird populations, it is useful to conduct surveys to discover whether changes in distribution and abundance of these species have been induced by wind energy development.

Understanding potential effects of wind energy development on shorebird populations begins with understanding potential changes in distribution. If these species are avoiding wind project areas then occupancy rates will be lower: effectively reducing the amount of available habitat for breeding shorebirds and ultimately reducing the carrying capacity of the landscape for these species. A first step in the process of discovering relationships between shorebirds and wind energy is to investigate patterns of occupancy and use of the landscape by these species. Then, other parameters can be studied in the context of how shorebirds are dispersed across the landscape in areas with and without wind energy development.

We conducted a three-year study of shorebird use of wetlands in wind projects and reference areas near Kulm, ND. Our primary objective was to compare the probability of presence and detection of shorebirds on wetland basins in wind projects and reference sites with similar land-use and environmental conditions. We predicted that the basin-level probability of presence and detection of shorebirds would be lower on wind-developed sites if wind development was having a negative effect on shorebird behavior.

Study Area

Two wind projects located in the PPR of south-central North Dakota and north-central South Dakota were selected as primary study sites. These two wind developments represented much of the currently active wind generation in areas of high wetland basin density and were located in an area with a large wind resource and extensive planned development. The Kulm-Edgeley (KE) wind farm was operated by Florida Power & Light Company, comprised 41 operational towers, and was located 2 miles east of Kulm, ND (Fig. 1). The Tatanka (TAT) wind farm was operated by Acciona Energy, comprised 120 towers, and was located 6 miles northeast of Long Lake, South Dakota. Approximately 50% of the towers at TAT were operational by 28 April 2008 and all were operational prior to 21 May 2008.

Three potential reference sites of approximately the same land area as the wind projects were identified for comparison. The most similar of the three potential sites was selected as a reference for each wind site. Proximity to corresponding wind site, land-use, wetland density, total wetland acres, and wetland class composition were considered in the selection of the reference sites. The KE reference site was located 7 miles southwest of the KE wind site and the TAT reference site was located 2 miles northwest of the TAT wind site.

Methods

Shorebird surveys were conducted by trained observers during two periods. The first count took place over roughly two weeks in late-April and early-May. The second count took place over roughly two weeks in late-May and early-June. Survey methods were similar to those used by Niemuth et al. (2006). Access permission was requested for the land area within each site when a landowner or tenant could be identified and contacted. On lands where access permission was secured, all wetland basins were sampled. The number and area of wetland basins surveyed varied between counts and years because of changes in wetland conditions and access permission. Observers also opportunistically sampled wetland basins from public section lines, adjacent land where permission had been obtained, or public roads on lands where we were unable to obtain access. Observers recorded the presence or apparent absence of marbled godwits, willets, and Wilson’s phalaropes on all of the visible wetland area of each basin within 220 yards of the viewpoint. The extent of the wet area of the wetland was estimated as percent full relative to the National Wetlands Inventory (NWI; United States Fish and Wildlife Service 2010) polygon on the field survey map. Wetland cover class (Stewart and Kantrud 1971) was also recorded. Surveys conducted from a public road were identified as roadside surveys for analysis. Basins with no surface water were recorded as dry and were not surveyed.

We analyzed the presence/non-detection data that resulted from our basin level survey with logistic regression (Agresti 2007). We modeled observed presence of shorebirds as a logistic-linear function of study site; year; wetland cover class; survey type (roadside or non-roadside); adjacent upland landcover (cropland or perennial cover); wet area and square root wet area of each basin. The full model included 23 parameters: an intercept for seasonal basins on the KE reference site in 2008; adjustments for the other three study sites; adjustments for year (2009 and 2010); adjustments for the six interaction terms of site and year; adjustments for semipermanent and temporary basins; a slope term for wet area of the basin, a slope term for the square root of wet area, and a third slope term for the interaction of wet area and square root of wet area. We discriminated among reduced versions of the full model using AIC (Burnham and Anderson 2002). Specifically, we evaluated the contribution to the likelihood of parameters or subsets of parameters by holding out one parameter or subset of parameters at a time and recording the change in the AIC value relative to the full model (Chambers 1992, Zuur et al. 2009). We then created a more parsimonious approximating model with the subset of parameters that were associated with increases in AIC relative to the full model when separately held out.

We used the R language and environment (R 2.10.1; R Development Core Team 2010) to generate estimates of parameters and sampling variances and AIC values for each model. We calculated the Receiver Operating Characteristic (ROC) curve (Agresti 2007) for each reduced model and compared the AIC of the reduced model with the AIC of the full model to evaluate the improvement in parsimony associated with reducing the model. We repeated this procedure for each of the study species and for all three species combined.

Once we had selected a reduced model for each species and for the three species combined, we compared site-level model coefficients and their sampling variances to gain insight about possible differences among sites. We used the Delta Method (Williams et al. 2002) to estimate the sampling variance of site-level estimates of mean probability of presence and detection.

Results

We surveyed 10,470 wetland basins for shorebirds during 2008, 2009, and 2010. The study species were present on 453 (or about 4%) of surveyed basins. The number of surveyed basins increased considerably in 2009 and 2010 due to changes in precipitation and resulting changes in wetland conditions. Among sites, years, and across a range of basin area from 0.001 acres to 686.611 acres, detections of the study species were rare (0% to 14% of total observations; Table 1). The best-approximating reduced model for all three species combined showed that basin-level probability of presence and detection varied among sites; was lower in 2009 and 2010 than in 2008; decreased with the amount of emergent cover on the basin; was lower in the second survey; was lower on basins near roadsides; decreased with basin wet area; increased with the square-root of basin wet area; and increased with the product of basin wet area and the square root of basin wet area (Table 2). The best-approximating reduced model for the three species combined represented a reduction of 6 AIC units from the full model. ROC curves indicated that our models provided a reasonable description of the data (Fig. 2). Reduced models for individual species did not contain site parameters (Table 2). Using the combined models to generate mean estimates, we observed little difference in mean probability of presence and detection among sites. Sampling distributions overlapped almost completely and differences in probability of presence and detection were small (Fig. 2).

Discussion

Our shorebird surveys in wind projects and reference areas provided no evidence of differential occupancy of wetland basins by shorebirds in wind developments and reference sites. Apparent presence was sparse on all sites. Thus, our conclusions about effects of wind development were weak. Changes in wetland conditions at the regional scale probably contributed to the overall reduction in basin-level occupancy between the drought year (2008) and the wet years (2009 and 2010). That is, when there are more wetland basins available, then, individual basin-level occupancy might be lower. Our study provided no support for the hypothesis that wind development was negatively affecting shorebird use of wetland basins on our study sites. Observed covariate relationships and mean estimates of probability of presence and detection were broadly consistent with a previous study conducted in the PPR that used very similar methods (Neimuth et al. 2006). Our models contained a suite of relevant covariates that controlled for variation among sites that was unrelated to our objective of comparing presence and detection of shorebirds on wetlands in landscapes with and without wind development. Sampling distributions of estimated probability of presence and detection overlapped among all of the study sites and although the Kulm-Edgeley wind site consistently had a lower mean than the other sites the effect size was small and associated with considerable density at zero. We therefore concluded that shorebirds have continued to use wetland basins on our study sites at a similar level regardless of wind development. We nevertheless caution that our data were probably too sparse to allow detection or estimation of subtle disturbance effects and that our sampling effort was not extensive enough in time or space to facilitate understanding of potential cumulative effects in the highly variable environment of the PPR. Low average densities of shorebirds present a challenge to researchers and managers seeking to understand potential effects of wind development on shorebird populations, and we suggest that strong conclusions will most likely continue to be elusive without substantial, ongoing research and monitoring efforts. These efforts would need to involve intensive (most likely repeated) sampling of wetland basins across extensive spatial and temporal scales.

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Table 1. Count of surveyed wetland basins where marbled godwit (*Limosa fedoa*), willet (*Tringa semipalmata*), or Wilson's phalarope (*Phalaropus tricolor*) were undetected or present during surveys of wind projects and reference sites without wind development in spring–summer 2008 , 2009, and 2010.

Site[1]	Year	Basin Class	Undetected	Present
KE_Ref	2008	Seasonal	158	17
		Semipermanent	42	12
		Temporary	33	1
	2009	Seasonal	274	12
		Semipermanent	31	4
		Temporary	175	4
	2010	Seasonal	413	25
		Semipermanent	61	7
		Temporary	402	10
KE_Wind	2008	Seasonal	168	5
		Semipermanent	61	5
		Temporary	37	0
	2009	Seasonal	478	11
		Semipermanent	48	3
		Temporary	205	2
	2010	Seasonal	533	10
		Semipermanent	52	2
		Temporary	297	4
TAT_Ref	2008	Seasonal	198	24
		Semipermanent	183	25
		Temporary	26	4
	2009	Seasonal	632	21
		Semipermanent	184	10
		Temporary	207	3
	2010	Seasonal	870	33
		Semipermanent	212	18
		Temporary	380	12
TAT_Wind	2008	Seasonal	580	19
		Semipermanent	382	53
		Temporary	74	0
	2009	Seasonal	610	17
		Semipermanent	266	24
		Temporary	165	1
	2010	Seasonal	902	28
		Semipermanent	360	24
		Temporary	318	3

[1] Sites were named according to location in the study area (Fig. 1) and development status. Full site names were Kulm-Edgeley Reference (KE_Ref), Kulm-Edgeley_Wind Project (KE_Wind), Tatanka Reference (TAT_Ref), and Tatanka Wind (TAT_Wind).

Table 2. Logit-scale parameter estimates from best-approximating, basin-level models of presence and detection of marbled godwit (*Limosa fedoa*), willet (*Tringa semipalmata*), and Wilson's phalarope (*Phalaropus tricolor*) on wind and reference sites in North and South Dakota during spring-summer 2008, 2009, and 2010.

	All Species		MAGO		WILL		WIPH	
Parameter	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
Intercept	-4.073	0.28	-4.285	0.167	-5.401	0.512	-5.754	0.599
site = KE_Wind	-0.478	0.19						
site = TAT_Ref	0.056	0.14						
site = TAT_Wind	0.028	0.14						
year = 2009	-0.853	0.14	-0.434	0.216	-0.719	0.232	-1.447	0.202
year = 2010	-0.616	0.12	0.089	0.174	-0.436	0.193	-1.895	0.209
KE_Wind*2009								
TAT_Ref*2009								
TAT_Wind*2009								
KE_Wind*2010								
TAT_Ref*2010								
TAT_Wind*2010								
basin regime = semipermanent							-0.244	0.179
basin regime = temporary							0.368	0.288
adjacent habitat = perennial								
cover class = 2	0.813	0.28			1.192	0.546	1.342	0.628
cover class = 3	1.063	0.26			1.361	0.522	2.015	0.595
cover class = 4	1.563	0.27			2.072	0.525	2.585	0.601
count = 2	0.231	0.10					0.538	0.161
survey type = roadside	-0.333	0.12	-0.738	0.205	-0.335	0.200		
wetarea	-1.290	0.20	-1.448	0.254	-0.312	0.078	-1.690	0.318
sqrt(wetarea)	1.486	0.13	1.744	0.182	0.799	0.103	1.783	0.224
wetarea*sqrt(wetarea)	0.058	0.01	0.063	0.015			0.075	0.019

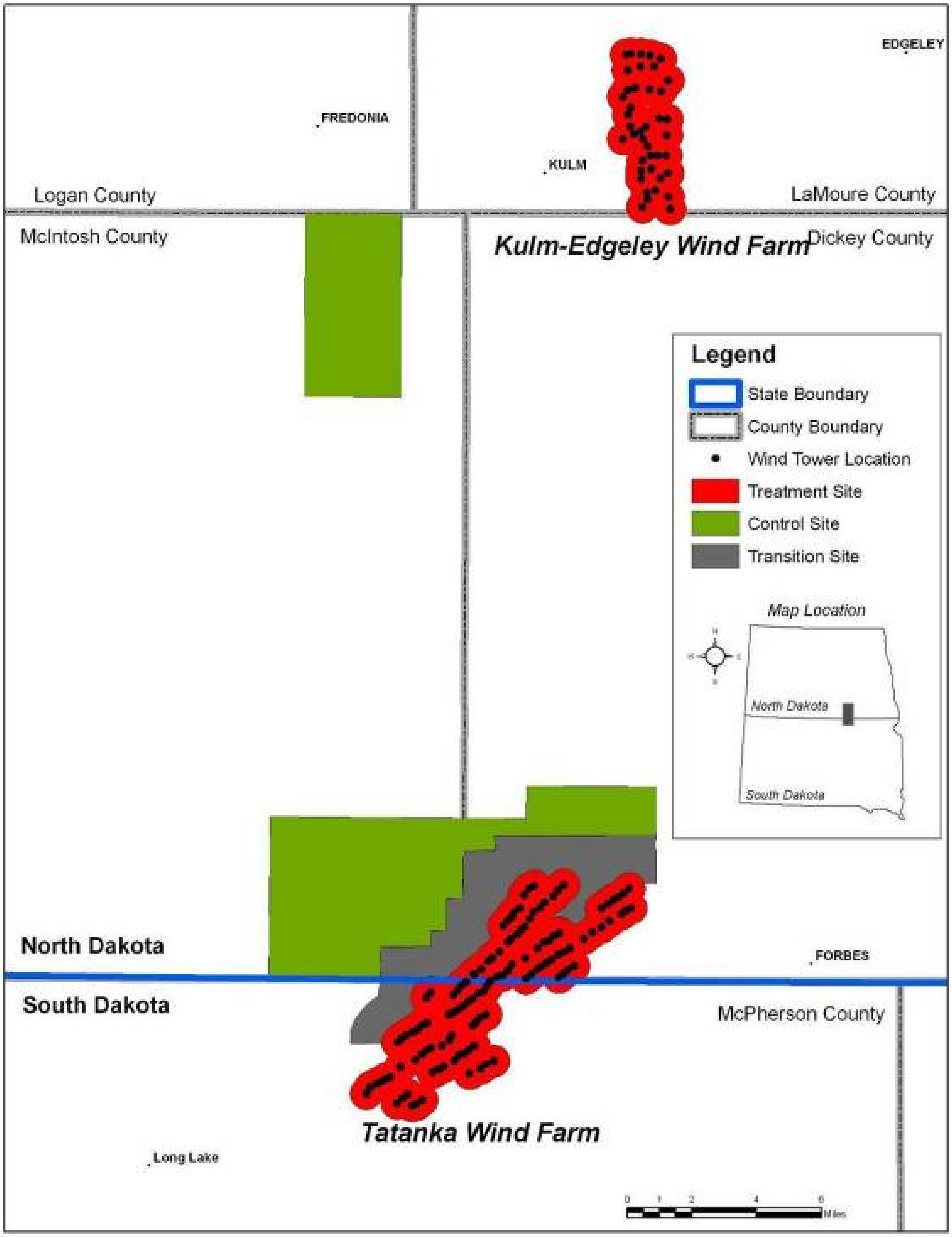

Figure 1. Location of wind (red polygons) and reference (green polygons) sites used for sampling wetland basins to compare presence and detection of shorebirds in areas with and without wind development during spring 2008, 2009, and 2010.

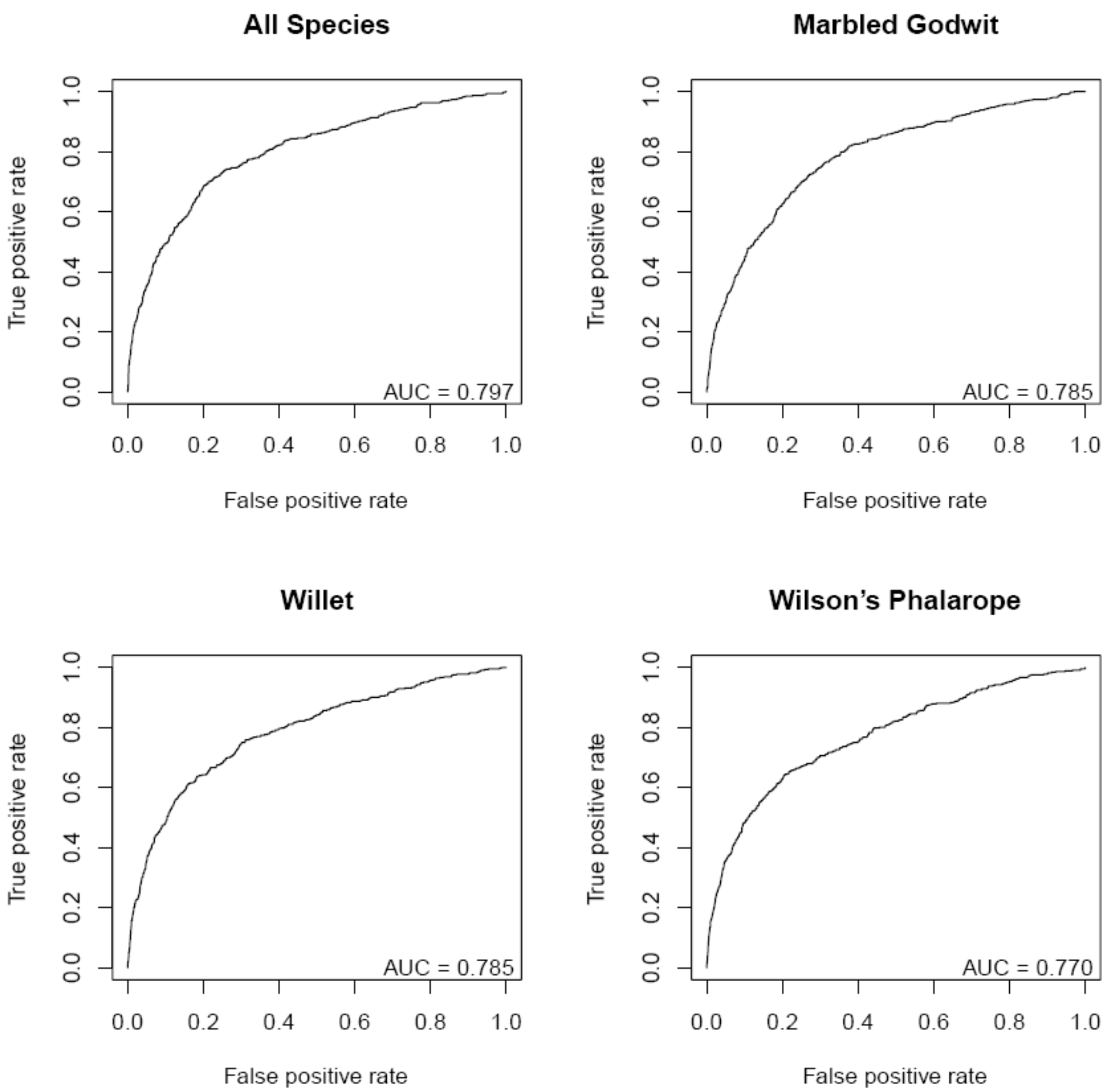

Figure 2. Receiver Operating Characteristic (ROC) curves of the best-approximating models of shorebird presence and detection on wetland basins in wind projects and reference areas. A perfect classifier would have an ROC curve concentrated at the point (0, 1). A perfectly random classifier would have true positive rate equal to false positive rate (i.e., y = x). This model showed better than random classification. The area under the curve (AUC) can be interpreted as an estimate of the probability that the model predicted a higher probability of presence and detection for a basin where shorebirds were present and detected.

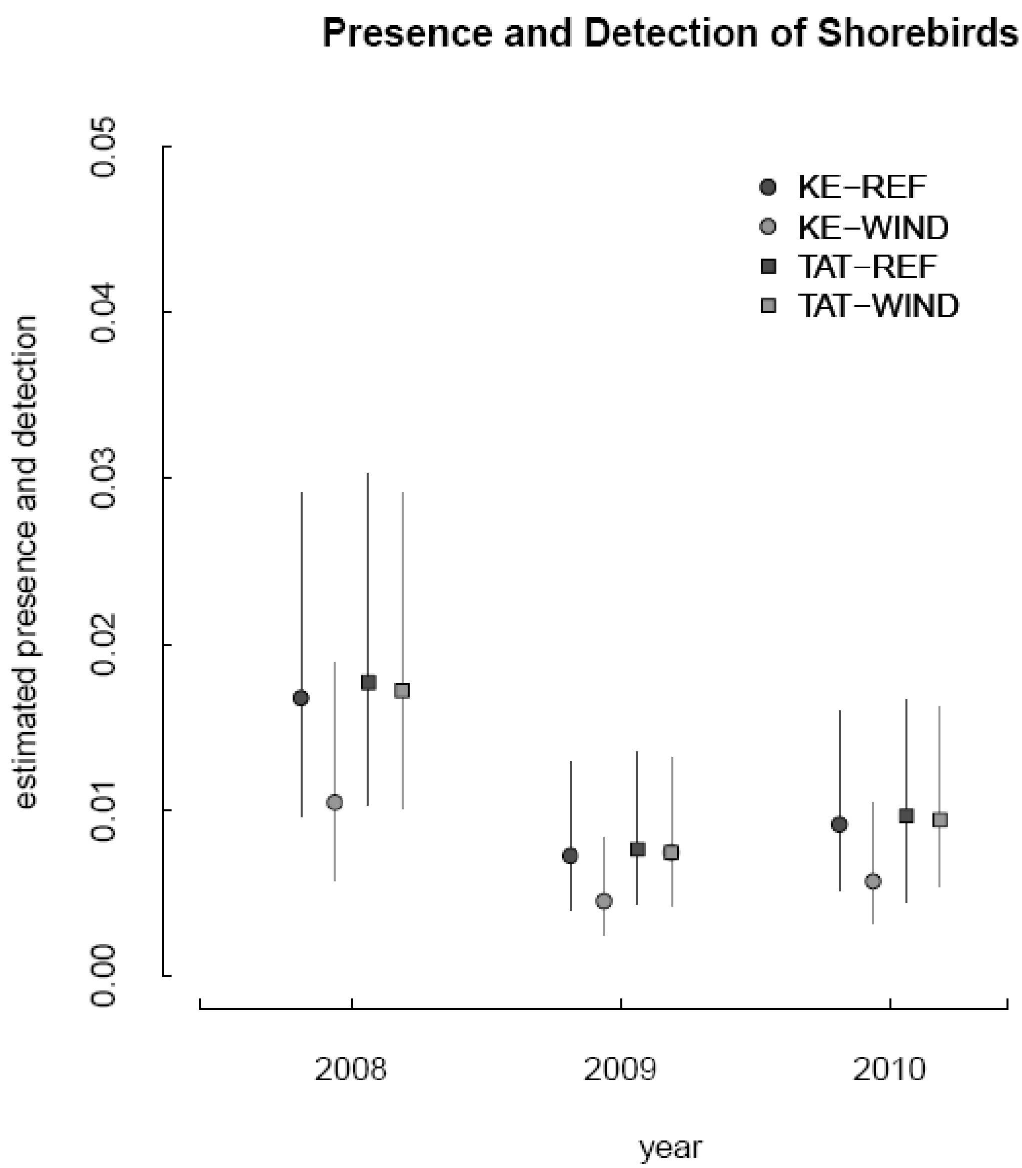

Figure 3. Site- and year-specific estimates of mean probability of presence and detection of marbled godwit (*Limosa fedoa*), willet (*Tringa semipalmata*), or Wilson's phalarope (*Phalaropus tricolor*) on wetland basins on study sites with wind development and no wind development. Lines are 95% confidence intervals. Site names are defined in Table 1.