Journal of Field Ornithology

J. Field Ornithol. 82(2):132–139, 2011 DOI: 10.1111/j.1557-9263.2011.00315.x

Abundance and population trends of mangrove landbirds in southwest Florida

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Received 27 October 2010; accepted 25 January 2011

ABSTRACT. The avifauna of south Florida's mangrove forests is unique and relatively unstudied. The population status of landbirds that breed in these forests is currently unknown, and this lack of information is especially problematic for species that have North American ranges limited almost exclusively to Florida's mangroves. To address this information gap, we estimated trends in abundance using data generated during bird surveys conducted from 2000 to 2008 at 101 points in mangrove forests in southwestern Florida. We found that populations of two of three mangrove-dependent species that breed in these forests, Black-whiskered Vireos (*Vireo altiloquus*) and Mangrove Cuckoos (*Coccyzus minor*), declined significantly during our study. In contrast, only one of seven species with a broader North American range (Red-bellied Woodpecker, *Melanerpes carolinensis*) declined in abundance. No species increased in abundance. The Mangrove Cuckoo population exhibited the greatest decline, with numbers declining 87.1% from 2000 to 2008. Numbers of Black-whiskered Vireos declined 63.9%. These declines coincided with the outbreak of West Nile virus that has been linked to population declines of other North American birds, but we could not rule out other potential causes, including changes in the quality or extent of breeding or wintering habitat.

RESUMEN. **Abundancia o tendencias poblacionales de aves terrestres de manglares en el suroeste de Florida**

La avifauna de los manglares del sur de la Florida, es única y ha sido poco estudiada. Actualmente se desconoce el estatus poblacional de las aves terrestres que anidan en estos bosques y esta falta de información es especialmente problemática para especies que tienen límites en su distribución a Norte America y que están limitadas exclusivamente a los manglares de la Florida. Para llenar este vacío de información, estimamos las tendencias en abundancia de estas aves, utilizando los datos generados durante los censos conducidos del 2000 al 2008 en 101 puntos de manglares en el sur de Florida. En dos de tres manglares encontramos que las poblaciones de especies, que son dependientes de estos, como el Julián Chiví (*Vireo altiloquus*) y el Pájaro Bobo Menor (*Coccyzus minor*), se redujeron significativamente, durante el periodo de estudio. En contraste, solo una de siete especies con una distribución más amplia (*Melanerpes carolinensis*) se redujo en abundancia. Ninguna especie mostró aumentos en su abundancia. El Pájaro Bobo Menor mostró el mayor descenso, con una reducción de 87.1% del 2000 al 2008. Por su parte el Julián Chiví se redujo en 63.9%. Estas reducciones coinciden con la llegada del virus de la fiebre del Nilo a Norte America que ha sido asociado a la reducción de otras aves, aunque no podemos dejar fuera otras causas incluyendo los cambios en la calidad y extensión del hábitat de anidamiento o el invernal.

Key words: Black-whiskered Vireo, Coccyzus minor, Mangrove Cuckoo, mangroves, population decline, Vireo altiloquus, West Nile virus

The mangrove forests of southern Florida support a unique avifauna, providing the primary North American breeding habitat for White-crowned Pigeons (*Patagioenas leucocephala*), Mangrove Cuckoos (*Coccyzus minor*), Black-whiskered Vireos (*Vireo altiloquus*), Cuban Yellow Warblers (*Dendroica petechia gundlachi*), and Florida Prairie Warblers (*Dendroica discolor paludicola*). Relatively little is known about the breeding biology and habitat requirements of these species (but see Wiley and Wiley 1979, Prather and Cruz 1995, 1996, 2002), and nothing is known about their population status. However, efficient allocation of conservation efforts requires some understanding of the status of these populations. Indeed, the lack of information about mangrove bird populations is a critical shortcoming that hinders development of scientifically defensible status assessments and precludes any proactive conservation efforts (USFWS 1999, Rich et al. 2004).

We addressed this lack of information by conducting point-count surveys in southwest

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Florida from 2000 to 2008 to estimate changes in abundance for three species closely associated with mangrove forests: Mangrove Cuckoo, Black-whiskered Vireo, and Florida Prairie Warbler. For comparison, we also examined trends in abundance over the same time period for seven more widely distributed members of the mangrove bird assemblage, including Red-bellied Woodpeckers (*Melanerpes carolinus*), Pileated Woodpeckers (*Dryocopus pileatus*), Great Crested Flycatchers (*Myiarchus crinitus*), White-eyed Vireos (*Vireo griseus*), American Crows (*Corvus brachyrhynchos*), Carolina Wrens (*Thryothorus ludovicianus*), and Northern Cardinals (*Cardinalis cardinalis*). Our objective was to examine short-term population trends of mangrove forest landbirds, both to assist land managers and conservation planners in their efforts to prioritize conservation efforts and to stimulate further study of an understudied bird assemblage.

METHODS

Study area. We conducted surveys at the Ten Thousand Islands National Wildlife Refuge, the Rookery Bay National Estuarine Research Reserve (tidal waters of the Refuge are co-managed with the Research Reserve), Collier-Seminole State Park, and Fakahatchee Strand Preserve State Park; these areas collectively comprise the northern half of the Ten Thousand Islands region (Fig. 1). The Ten Thousand Islands region extends for about 100 km along the southwest coast of Florida, and is characterized by an archipelago of small, mangrove-covered islands that parallel the mainland coast (Fig. 1). The region begins in Everglades National Park, near the town of Chokoloskee, and extends as far north as Marco Island.

Bird surveys and abundance estimates. A single observer (T. Doyle) recorded detections of individual birds during 10-min, unlimited-radius surveys at 101 points (Fig. 1). Survey points were selected systematically using 1:40,000 scale NOAA navigational charts to provide even coverage across the study area. Points that were not surrounded by at least 50% mangrove forest or were not accessible by boat were excluded. All points were at least 500 m apart and were combined into routes consisting of 11 to 14 points that could be surveyed within 4 h of sunrise. Generally, points were surveyed from south to north to take advantage of incoming tides. Survey points covered a range of forest conditions. Tall, closed mangrove forest, consisting of red (*Rhizophora mangle*), white (*Laguncularia racemosa*), and black (*Avicennia germinans*) mangroves, predominated, with a few small (<0.1 ha) areas of buttonwood (*Conocarpus erectus*) and tropical hardwood forest on beach ridges and shell mounds. Surveys ($N = 6$) were conducted during the period from 4 May to 15 June over a 9-yr period (2000–2002, 2004, 2006, and 2008). All surveys were conducted during the period from sunrise to 11:00.

We estimated abundance for each species as the arithmetic mean of the number of individuals counted per point per year. We used a non-parametric bootstrap routine to estimate 95% confidence intervals around observed means. This measure of abundance does not account for variation in detectability, but we attempted to control for inter-annual sources of variation in detectability by ensuring that all surveys were conducted by the same observer, during similar weather conditions, and at approximately the same time each year. Although numerous investigators have highlighted the problems associated with use of indices (e.g., Nichols et al. 2009), indices of abundance can provide useful insight into population trends (Johnson 2008) and, in practice, trend estimates based on uncorrected counts often mirror those based on corrected estimates of abundance (Thompson and La Sorte 2008: 1678–1679). From a pragmatic standpoint, we also believe that cautious presentation of results based on indices is preferable to the status quo, i.e., no information available for any of the focal species.

Population trends. We defined a trend as the annual rate of change in the average number of individuals counted per point. We estimated trends in abundances using generalized linear mixed models (GLMM), as implemented by the package lmer (Bates and Maechler 2009) in version 2.9.2 of R (R Development Core Team 2009). We assumed that counts followed a Poisson distribution and used the log link function. We treated survey point as a random effect to account for the repeated visits made to the same point in different years, and allowed both the intercept and the slope of the trend in abundance to vary at random among points. We included year as the fixed effect in each model. We assessed the extent to which fitted models

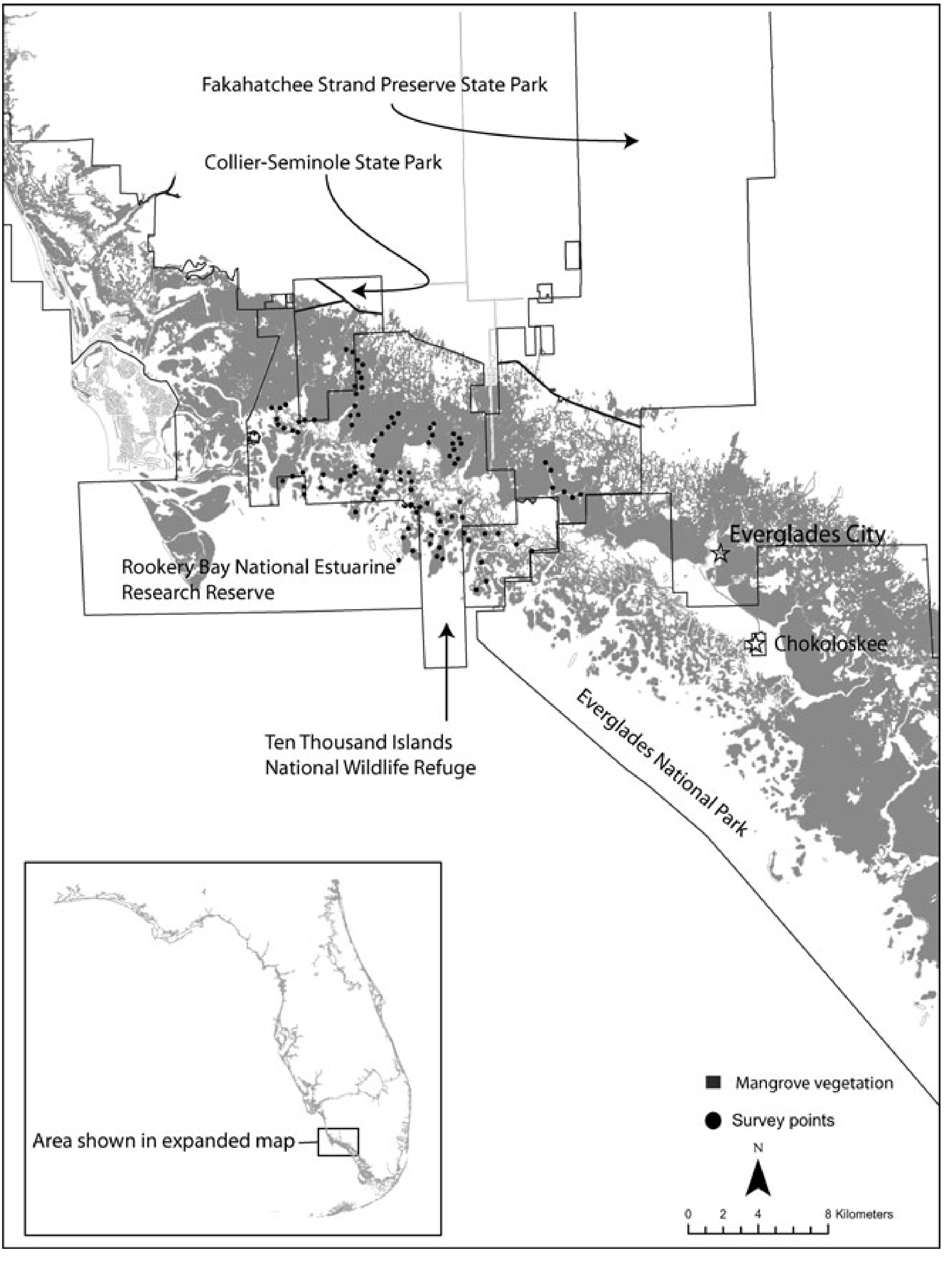

Fig. 1. Map of the study area in the Ten Thousand Islands region of southwest Florida showing extent of mangrove vegetation, location of points ($N = 101$) where bird surveys were conducted, and administrative boundaries. Surveys were conducted from 2000 to 2008.

corresponded to assumptions regarding the normality of residuals and constancy of variance by examining *Q–Q* plots and plots of fitted values versus residuals. We estimated overdispersion as the weighted sum of the squared Pearson residuals divided by the residual degrees of freedom, and tested whether this value was significantly different from 1, the expectation under the Poisson model, using a chi-square test. None of the models showed evidence of significant overdispersion or deviation from the assumptions of normality and homoscedasticity, so we did not make any adjustments. We estimated annual rates of change as the exponent of the parameter estimate for the fixed effect of year, and estimated overall rates of change by multiplying the parameter estimate for the effect of year by eight, the number of years covered by the counts. We used the delta method (Oehlert 1992) to estimate the variance of the estimate of overall rates of change.

RESULTS

Abundance estimates. The assemblage of birds breeding in mangrove forests in our study area was dominated by White-eyed Vireos, Red-bellied Woodpeckers, and Northern Cardinals (Table 1). Black-whiskered Vireos and Prairie Warblers were the fourth and fifth most abundant species, respectively, whereas Mangrove Cuckoos, a mangrove-dependent species, was among the least common species (Table 1).

Population trends. Estimated abundances of seven of 10 species showed no significant trends during our study. Northern Cardinals ($P = 0.20$), Prairie Warblers ($P = 0.59$), Great Crested Flycatchers ($P = 0.28$), Pileated Woodpeckers ($P = 0.26$), American Crows ($P = 0.37$), and Carolina Wrens ($P = 0.32$) all showed annual fluctuations, but with no consistent directional changes. For White-eyed Vireos, the slope parameter in the GLMM differed significantly from zero ($P = 0.03$), but the 95% confidence interval around the estimated annual trend overlapped zero (estimated annual increase: 2.4%, 95% CI = 0 – 4.8%). Numbers of White-eyed Vireos were therefore either stable or increased slightly from 2000 to 2008.

Three species, including one widespread species and two dependent on mangrove forests, showed significant declines in abundance from 2000 to 2008. Red-bellied Woodpeckers declined at an annual rate of 4.5% (95% CI = 2.3 – 6.6%; $P < 0.001$; Fig. 2), yielding a total estimated decline in abundance of 30.8% (95% CI = 17.3 – 42.2%). Numbers of Black-whiskered Vireos declined at an annual rate of 11.9% per year (95% CI = 8.6 – 15.1%; $P < 0.001$; Fig. 3), or 63.9% (95% CI = 51.4–73.1%) over the course of our study. Confidence intervals around the model-generated estimates of abundance overlapped those around the observed estimates of abundance (Fig. 3), but the trend in observed estimates suggested a stepped, rather than linear, decline. Most of the decline in abundance of Black-whiskered Vireos occurred from 2002 to 2004 (Fig. 3).

Mangrove Cuckoos exhibited the most significant decline. We detected 66 Mangrove Cuckoos in 2002, whereas, on the same routes and with the same observer, only eight were detected in 2008. The average number of Mangrove Cuckoos detected per point declined significantly from 2000 to 2008 (Fig. 4), at an estimated annual rate of 22.6% (95% CI = 16.6 – 28.1%; $P < 0.001$). From 2000 to 2008, numbers of Mangrove Cuckoos were estimated to have dropped by 87.1% (95% CI = 77.2–92.7%).

DISCUSSION

Abundance estimates. The assemblage of landbirds breeding in mangrove forests in the Ten Thousand Islands region of southwest Florida was dominated by widespread species common in south Florida. Of the species with North American ranges limited to mangrove forest, Black-whiskered Vireos and Florida Prairie Warblers were most abundant. Mangrove Cuckoos were the fifth most abundant species in 2000 ($N = 66$), but only eight were detected in 2008, making them the rarest of the mangrove landbirds.

Population trends. Three of 10 species in our study showed significant declines in the mean number of individuals counted per point, with Mangrove Cuckoos, Black-whiskered Vireos, and Red-bellied Woodpeckers exhibiting the greatest declines. We acknowledge that trend estimates were based on uncorrected counts, and were thus potentially confounded with changes in detectability, but believe it is unlikely that either Mangrove Cuckoos or Black-whiskered Vireo populations have not declined

Table 1. Mean number of individuals (and 95% confidence intervals) counted per point during 10-min surveys conducted from 2000 to 2008 in mangrove forests in the Ten Thousand Islands region of southwest Florida.

	Year[a]						
Species	2000 ($N = 88$)	2001 ($N = 101$)	2002 ($N = 101$)	2004 ($N = 101$)	2006 ($N = 101$)	2008 ($N = 100$)	All years
White-eyed Vireo	1.78 (1.51–2.06)	1.56 (1.34–1.80)	2.04 (1.80–2.29)	1.81 (1.58–2.04)	1.77 (1.50–2.04)	1.70 (1.46–1.93)	1.78 (1.62–1.95)
Red-bellied Woodpecker	2.01 (1.78–2.23)	1.93 (1.75–2.13)	1.74 (1.53–1.99)	2.10 (1.87–2.36)	1.38 (1.10–1.67)	1.37 (1.16–1.61)	1.76 (1.56–1.98)
Northern Cardinal	1.40 (1.20–1.59)	1.09 (0.92–1.27)	1.19 (0.98–1.40)	1.15 (0.97–1.34)	1.25 (0.80–1.54)	1.03 (0.84–1.22)	1.19 (1.09–1.28)
Black-whiskered Vireo	1.18 (0.96–1.42)	0.92 (0.74–1.10)	0.94(0.75–1.15)	0.51 (0.38–0.63)	0.47 (0.26–0.70)	0.51 (0.36–0.66)	0.76 (0.55–0.97)
Prairie Warbler	0.63 (0.49–0.78)	0.57 (0.46–0.68)	0.46 (0.34–0.58)	0.34 (0.25–0.46)	0.53 (0.36–0.69)	0.56 (0.45–0.68)	0.52 (0.42–0.61)
Pileated Woodpecker	0.62 (0.49–0.77)	0.34 (0.24–0.45)	0.38 (0.28–0.52)	0.50 (0.37–0.64)	0.48 (0.31–0.67)	0.58 (0.43–0.74)	0.48 (0.41–0.57)
Great Crested Flycatcher	0.49 (0.34–0.64)	0.47 (0.36–0.59)	0.29 (0.19–0.39)	0.48 (0.35–0.59)	0.49 (0.30–0.69)	0.53 (0.38–0.67)	0.46 (0.40–0.52)
American Crow	0.44 (0.32–0.58)	0.33 (0.22–0.45)	0.29 (0.19–0.41)	0.15 (0.07–0.24)	0.25 (0.12–0.38)	0.38 (0.25–0.52)	0.31 (0.23–0.37)
Mangrove Cuckoo	0.74 (0.56–0.93)	0.25 (0.17–0.37)	0.36 (0.23–0.49)	0.30 (0.19–0.41)	0.10 (0.02–0.19)	0.08 (0.03–0.14)	0.31 (0.18–0.48)
Carolina Wren	0.21 (0.12–0.30)	0.28 (0.18–0.38)	0.33 (0.22–0.46)	0.29 (0.17–0.40)	0.31 (0.12–0.51)	0.34 (0.23–0.47)	0.29 (0.20–0.38)

[a]The number of surveys conducted each year is indicated in parentheses.

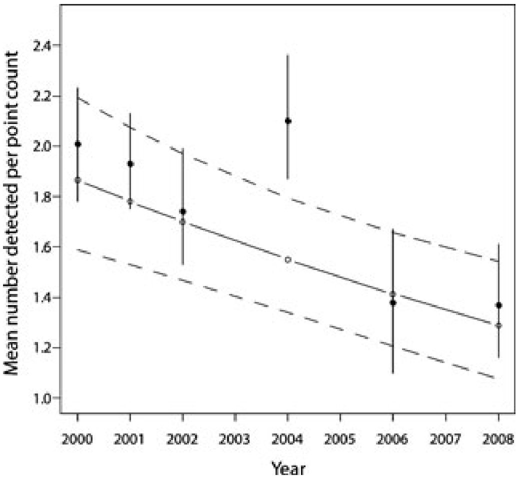

Fig. 2. Estimated trend (solid line; dotted lines are 95% confidence limits) and point estimates (open circles) of abundance of Red-bellied Woodpeckers in the Ten Thousand Islands region of southwest Florida from 2000 to 2008 as generated by a GLMM. Closed circles show observed abundance; bars are 95% confidence intervals.

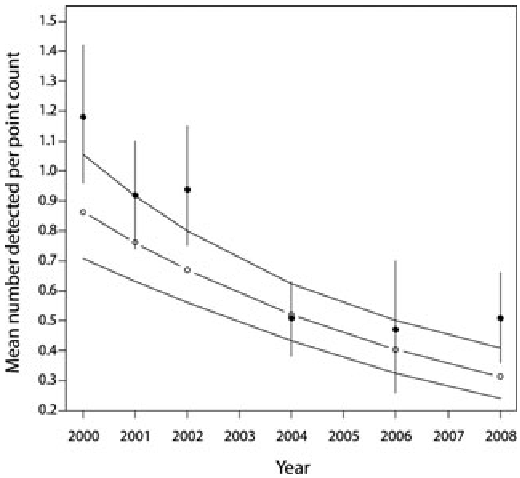

Fig. 3. Estimated trend (solid line; dotted lines are 95% confidence limits) and point estimates (open circles) of abundance of Black-whiskered Vireos in the Ten Thousand Islands region of southwest Florida from 2000 to 2008 as generated by a GLMM. Closed circles show observed abundance; bars are 95% confidence intervals.

in our study area. Our surveys were conducted by the same observer, at approximately the same time each year, in a relatively stable habitat likely to afford similar acoustic conditions among years. We do not know if the trends we detected are indicative of range-wide trends, nor do we know the cause(s) of the observed declines.

Almost all mangrove vegetation in the Ten Thousand Islands region is protected, so we can rule out loss of habitat as a potential cause of the declines. One possibility is that the decline in the number of Mangrove Cuckoos and Black-whiskered Vireos in our study reflects the position of our study area at the northern edge of their geographic ranges. Individuals in peripheral populations are often poorly adapted to the rigors of their environment and thus sensitive to even slight variation in environmental conditions (Brown et al. 1996). As a consequence, temporal variation in population size is much greater at the edge of a species' range than near the core, and peripheral populations may be more likely to exhibit boom-and-bust cycles in response to fluctuations in abiotic conditions (Thomas et al. 1994, Curnutt et al. 1996).

Changes in the amount of mangrove vegetation in our study area due, for example, to damage from hurricanes or sub-freezing temperatures might also explain the declines. However, we observed no significant changes in the extent or structure of mangrove vegetation during our

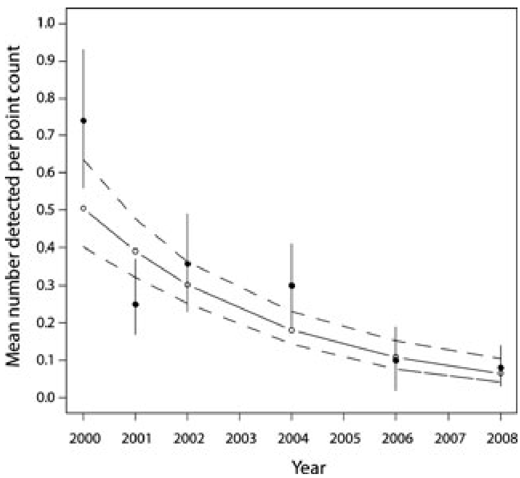

Fig. 4. Estimated trend (solid line; dotted lines are 95% confidence limits) and point estimates (open circles) of abundance of Mangrove Cuckoos in the Ten Thousand Islands region of southwest Florida from 2000 to 2008 as generated by a GLMM. Closed circles show observed abundance; bars are 95% confidence intervals.

study and, in addition, it is not clear why any changes in vegetation would cause declines in only a subset of the species that depend on mangroves. Diminished quality or extent of wintering habitat might have contributed to the decline, but available data are insufficient to evaluate this hypothesis. The location of the wintering area of Florida's Black-whiskered Vireos is unknown, and the status of Mangrove Cuckoos (i.e., migratory or year-round resident in Florida) is also unknown.

Another possible cause of population declines in our study is West Nile virus (WNV). Many species in our study, even those that did not show significant trends in abundance, were least abundant in 2004 when there was a large-scale epidemic of WNV among humans in the United States and when population declines of other bird species were putatively caused by WNV (LaDeau et al. 2007). Mortality due to WNV has been confirmed for two species that showed significant declines in numbers in our study (Black-whiskered Vireos and Red-bellied Woodpeckers) and has also been confirmed in Yellow-billed Cuckoos (*Coccyzus americanus*), a congener of Mangrove Cuckoos (CDC 2009). In addition, antibodies to WNV were isolated from a Mangrove Cuckoo collected in the Dominican Republic in 2002 (Komar et al. 2003). If the declines we observed were due to WNV, the failure of Mangrove Cuckoo and Black-whiskered Vireo populations to recover may reflect a lack of large, regional pools of individuals that could bolster populations in the study area via immigration. Most other members of the mangrove bird assemblage are more widespread and abundant in southern Florida and their populations may therefore have been better able to recover.

Unfortunately, we do not know what caused the decline of Black-whiskered Vireo and Mangrove Cuckoo populations in our study, and we know so little about their natural history that it is difficult to even formulate hypotheses. For example, we do not know if Mangrove Cuckoos in Florida are migratory or resident and, therefore, whether the population declines observed in our study might reflect factors operating elsewhere. Nearly nothing is known about survivorship or reproduction in North American populations of either species, and so the potential impact of nest predators or nest parasites on their population status remains unknown. The decline of the Red-bellied Woodpecker population in our study, although troubling, is of less significance because this species is widespread and demonstrably secure throughout much of its range. Therefore, future research and monitoring should focus on the species limited to mangrove forests. In particular, we recommend: (1) continued monitoring of populations of Black-whiskered Vireos and Mangrove Cuckoos in the Ten Thousands Islands region, along with an effort to formulate and test hypotheses to explain the observed declines, including the possibility that declines were linked to WNV, (2) initiation of a range-wide monitoring effort targeting the three mangrove-associated species in our study (Mangrove Cuckoo, Black-whiskered Vireo, and Florida Prairie Warbler) as well as Cuban Yellow Warblers to determine if the declines we observed are reflective of regional population trends, and (3) studies to improve our knowledge of the natural history, including habitat requirements, of Black-whiskered Vireos and Mangrove Cuckoos in the hope that such information will help us better understand the possible causes of the observed declines.

ACKNOWLEDGMENTS

This project was funded in part through a cooperative agreement (CA no. 401818J604) between USFWS and Ecostudies Institute. We thank J. Palmer for continued support of our research and monitoring efforts. The findings and conclusions in this article are those of the authors and do not necessarily represent the views of the U.S. Fish and Wildlife Service.

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