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POPULATION TRENDS IN THE EXOTIC RED-MASKED PARAKEET (*Psittacara erythrogenys*) IN SOUTHERN FLORIDA

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Abstract.—The Red-masked Parakeet (*Psittacara erythrogenys*) was introduced into south Florida in 1986 and has since expanded its population and range. We examined these trends using data from the Cornell Lab of Ornithology's eBird project and the National Audubon Society's Christmas Bird Counts over the past 15 years. The results suggest that after a period of rapid growth, population size has remained relatively level since 2011. The Red-masked Parakeet in south Florida exhibits characteristics of an established invasive species.

Key words: Florida, invasive species, population trends, Red-masked Parakeet

INTRODUCTION

Florida's introduced avifauna includes more than 50 species of parrots and parakeets (Greenlaw et al. 2014). Only four of these have so far become numerous and persistent enough to have been considered established as breeding populations in the state (Greenlaw et al. 2014). The Red-masked Parakeet (*Psittacara erythrogenys*) is a small parrot native to southern Ecuador and northern Peru (Best et al. 1995). From 17,000 to 30,000 individuals were imported into the United States for the pet trade between 1983 and 1985 (Best et al. 1995). The species was first officially recorded in Florida when 30 individuals were counted on the 1989 Dade County Christmas Bird Count (CBC) in Miami (National Audubon Society 2010). Though James (1997) considered the population unlikely to persist through the 1990s, the Miami population

has since expanded in population size and range. A second population is now established in Fort Lauderdale, reaching 355 birds in 2004 (Pranty and Epps 2002; S. Epps, pers. obs.).

Breeding populations of Red-masked Parakeets in Florida exhibit long-term fidelity to specific sites and show solitary and colonial breeding strategies (eBird Basic Dataset 2019; S. Epps, pers. obs.). Red-masked Parakeets are secondary cavity nesters and will also nest in live royal palms (*Roystonea regia*) in Florida (Diamond and Ross 2019, Epps 2007)

Investigators often monitor population trends of exotic parrots (Runde et al. 2007, Pârâu et al. 2016, Uehling et al. 2019). Some species are considered crop pests (*Amazona* spp.), disease carriers, or competitors with native species (Pithon and Dytham 1999, Runde et al. 2007). Red-masked Parakeets have been monitored for conservation (Chavez-Riva 1994) and to determine the extent to which they have become established in a given location (Pranty and Epps 2002, Runde et al. 2007). Monitoring efforts have largely relied on annual CBC data from urbanized areas (Pranty and Epps 2002, Runde et al. 2007). The CBC is also useful for monitoring range expansion as is the Cornell Lab of Ornithology's eBird citizen science project. We applied a combination of statistical and descriptive geospatial analyses to describe population trends and range expansion of the Red-masked Parakeet, and evaluated its current status in Florida.

METHODS

Collection of data and nesting reports.—We collected data on distribution, numbers, and breeding status from eBird's Basic Dataset (2019), CBCs, primary literature, and personal observations. Christmas Bird Counts provide a consistent methodology for tracking species counts in an area and have been used previously to monitor invasive parrot populations (Pranty and Epps 2002, Runde et al. 2007). We used data from three CBCs: Dade County, Fort Lauderdale, and Kendall. More recently, eBird has also been used to monitor invasive species, including parrots (Uehling et al. 2019).

We edited raw, georeferenced eBird data to remove redundant records and converted them to a geographic information system shapefile for use in ArcMap 10.1 (Esri, Redlands, CA, USA). We filtered this data to find verified reports of nesting Red-masked Parakeet and supplemented these data with Diamond and Ross (2019), Pranty and Epps (2002), and personal observations from the second author. Because of the lack of historical data in eBird before 2003 and issues with the identification of *Psittacara* before 2000, we restricted our analysis to 2004–2018.

The count circle data provided by the National Audubon Society are pooled by state and include bird counts and party-hours spent. We performed two regression analyses: one with year as a predictor of count, and the second using party-hours as a covariate to correct for effort. We calculated both R^2 values to determine whether the addition of the covariate explained the variation in the raw count data. No correction was possible for the eBird data.

Analysis of overall population trends.—Using eBird, Pranty and Epps (2002), and our personal observations, we determined the greatest number of Red-masked Parakeets counted from a single report in each year from 2004–2018 (Table 1). Unlike pooled CBC data, these point counts do not need to be corrected for effort. We compared the CBC and yearly

Table 1. Yearly single high count of Red-masked Parakeets in Florida.

Year	High count	Locality	County	Date
2000	53	Las Olas Isle	Broward	17 Dec 2000
2001	36	Nurmi Isle	Broward	8 Nov 2001
2002	65	Navrro Isle	Broward	13 Nov 2002
2003	120	Coconut Isle	Broward	1 Jan 2003
2004	355	Las Olas Isle	Broward	19 Dec 2004
2005	18	Ft. Lauderdale Hampton Inn	Broward	5 Nov 2005
2006	2	Matheson Hammock Park	Miami-Dade	29 Apr 2006
2007	60	Matheson Hammock Park	Miami-Dade	12 Dec 2007
2008	15	18th Court Neighborhood, Ft. Lauderdale	Broward	29 Sep 2008
2009	75	NW 2nd Avenue and Garden Drive	Miami-Dade	17 Jan 2009
2010	30	Matheson Hammock Park	Miami-Dade	15 Jan 2010
2011	280	Las Olas Isle	Broward	29 Jan 2011
2012	62	Hollywood Lakes	Broward	14 Nov 2012
2013	51	Matheson Hammock Park	Miami-Dade	11 Jan 2013
2014	80	Miller Roost	Miami-Dade	23 Mar 2014
2015	70	Golden Glades	Miami-Dade	19 Nov 2015
2016	80	Miller Roost	Miami-Dade	20 Apr 2016
2017	150	SW 16th Street and 82nd Avenue	Miami-Dade	17 Mar 2017
2018	80	82nd south of 8th Street	Miami-Dade	16 Oct 2018

high counts using a two-sample t -test for significant difference. This allowed us to determine if the covariate correction truly explained the observed pattern.

Using a spatial methodology similar to the one employed by Davis et al. (2011), we used ArcGIS (Esri, Redlands, CA, USA) to group eBird data to match the period of CBC counts and extracted the corresponding population data. This provided an approximation of the population during the same temporal period as the CBCs. For each year, we chose the higher value (CBC vs. spatial analysis) because CBCs are generally undercounted. We used these data for the *post hoc* analysis, which compared pre- and post-2011 variance in population counts with an F -test. We calculated statistics using R (R Foundation for Statistical Computing, Vienna, Austria) using the *drc* package (Ritz et al. 2015).

RESULTS

There are currently 5 breeding sites in Miami-Dade County with multiple recent reports: Miami Springs, Fuchs Park, Matheson Hammock, the Miller Roost in Brewster Park, and the Biltmore Hotel (where breeding began circa 1997; eBird Basic Dataset 2019; L. Manfredi, Larry Manfredi Birding Tours Inc., pers. comm.). In Broward County, there are reports of breeding at Richardson Historic Park and Nature Center as recent as 2019: 5 kilometers away from where the second author reported breeding in multiple locations in the Las Olas Isles in 2001 (Fig. 1; eBird Basic Dataset 2019; S. Epps, pers. obs.). The observations from Richardson Historic Park may indicate that Red-masked Parakeets have bred in the vicinity during this 18-year period.

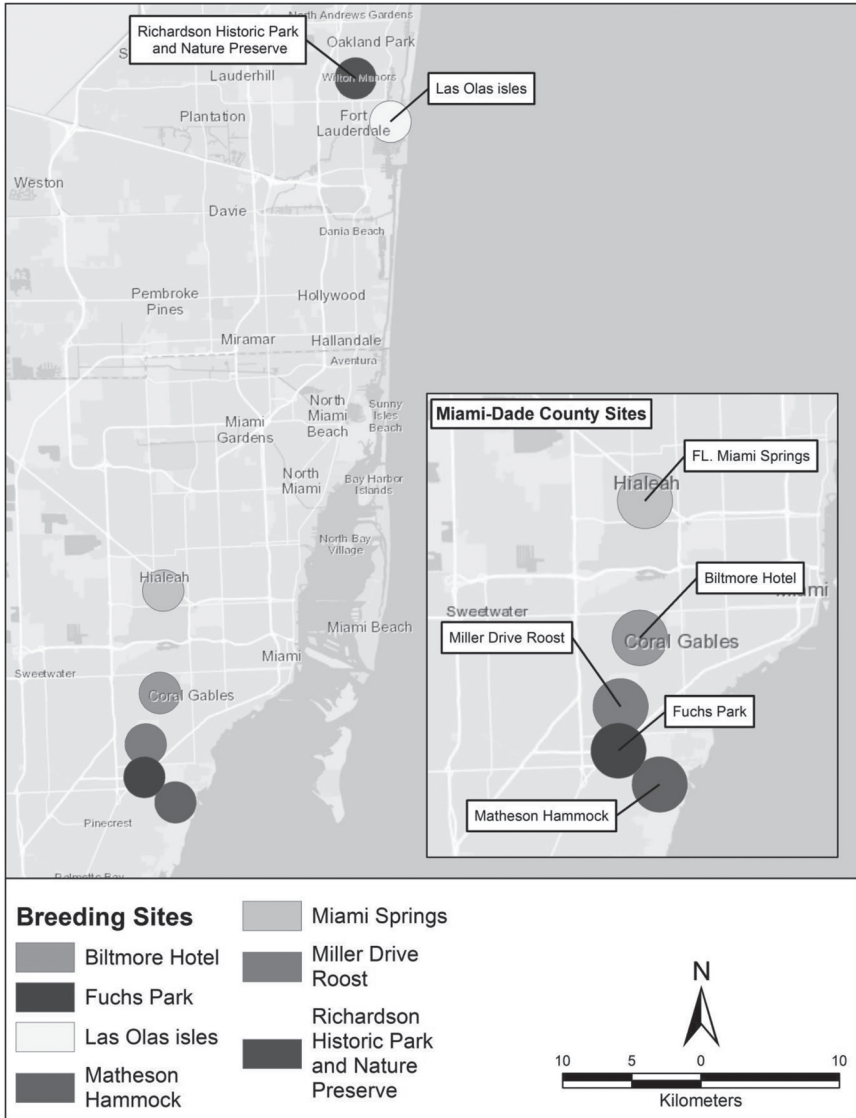


Figure 1. Map of major breeding sites of Red-masked Parakeets in Florida, 1997-2018.

Records indicated 45 instances of nesting, mating, or the presence of juveniles (Table 2).

Variation in bird count was not explained by year ($R^2 = 0.06$). Nearly 100% of the variation was explained by the amount of effort expended (party-hours; $R^2 = 0.998$). The uncorrected CBC data was similar to the individual yearly high counts ($t = -1.12, P = 0.27$). We decided to use the

Table 2. Location of Red-masked Parakeet nesting records in Florida from 1997 to 2019 and literature sources.

Locality	County	Date	Comments ^a
Biltmore Hotel	Miami-Dade	1997	*
Coral Ridge	Broward	15 Jul 1999	†
Victoria Park	Broward	2001	†
Wilton Manors	Broward	2001	†
Hendrick's Isle	Broward	6 Feb 2001	Saw several pairs mating in the Australian Pines at 110 Hendricks Isle.*
Kensington Place	Broward	14 Feb 2001	Several pairs checking out nest holes. I saw pairs at 4 or 5 different nest holes.*
Kensington Place	Broward	17 May 2001	Pair seen copulating on a wire in front of their nest hole. Two women from the neighborhood approached me to tell me they had seen the pair feeding a nestling in the nest the previous Sat. Two more women told me they had seen the same thing on other days.*
Jefferson and 16th	Broward	16 Aug 2001	4 at NE 16th Ave. and NE 8th St. Got photos of 2 at the nest hole.*
NE 16th Ave. and NE 8th St.	Broward	26 Aug 2001	2 at a nest hole in a Royal Palm. Appeared to be feeding nestlings.*
Rio Vista	Broward	2002	†
Wilton Manors	Broward	2002	†
Collee Hammock	Broward	13 Jun 2003	A pair peeking out of a nest hole at Collee Hammock.*
Ft. Lauderdale		2002	†
Miami Springs	Miami-Dade	7 Dec 2010	Two adults (pair) with two fledged young.
Matheson Hammock Park	Miami-Dade	19 Apr 2013	Seen flying and in nest cavity hanging out and creating a ruckus.
Matheson Hammock Park	Miami-Dade	28 Apr 2013	Observed both parrots going in & out of nesting cavity, close enough to see more red on face than on Mitered Parrots.

^aData sources: ‡ = Diamond and Ross (2019); * = personal observations by S. Epps, L. Manfredi, and D. Click; † = Pranty and Epps 2002; all other records from eBird Basic Dataset (2019).

Table 2. (Continued) Location of Red-masked Parakeet nesting records in Florida from 1997 to 2019 and literature sources.

Locality	County	Date	Comments ^a
Matheson Hammock Park	Miami-Dade	5 May 2013	A pair investigating a royal palm with woodpecker cavities...possible nest location; red along the leading edge of the wing.
Matheson Hammock Park	Miami-Dade	2 Jun 2013	Two pair nesting in the area; red visible on leading edge of wings in flight.
Matheson Hammock Park	Miami-Dade	9 Jun 2013	Peering out of a nest cavity in a royal palm.
Matheson Hammock Park	Miami-Dade	6 Apr 2014	Regular at this location. Medium-sized parakeet with a bright red face and pale yellow orbital rings. Two were inside a cavity in a Royal Palm snag.
Matheson Hammock Park	Miami-Dade	30 Jan 2015	Juveniles and adults. Juvies had red knob above the bill along with red speckling on shoulders and breast. Some red coming in on underwing coverts. Observers here should be careful to not confuse juvenile RMPA with other parakeets (Mitreid, White-eyed, etc.). Adults had extensive red on faces and underwing coverts.
Matheson Hammock Park	Miami-Dade	1 Feb 2015	Presumably checking out a cavity for potential nesting on West side of Matheson Hammock.
Matheson Hammock Park	Miami-Dade	13 Feb 2015	Large parakeets with white orbital wings. Juveniles and adults present. Red masks on adults, red foreheads on first year birds. Red underwing coverts. None seemed large enough to be Mitred.
Miami Springs	Miami-Dade	16 Feb 2015	Red bend on wing. Appear to be nesting in back of a local motel near Best Western. Male has all red head.
Matheson Hammock Park	Miami-Dade	23 Mar 2015	All visible at once; pix to come. 8 flew off together, 2 investigated potential nest hole repeatedly.

^aData sources: ‡ = Diamond and Ross (2019); * = personal observations by S. Epps, L. Manfredi, and D. Click; † = Pranty and Epps 2002; all other records from eBird Basic Dataset (2019).

Table 2. (Continued) Location of Red-masked Parakeet nesting records in Florida from 1997 to 2019 and literature sources.

Locality	County	Date	Comments ^a
A. D. Barnes Park	Miami-Dade	22 Apr 2015	Completely red head, red in bend of wing. Seen perched as close as 30 feet away. Apparently nesting in Palm snags.
A. D. Barnes Park	Miami-Dade	2 Jun 2015	2 birds on same nesting hole as in past. No speckling red on head.
USA Miami Shores Golf Club	Miami-Dade	16 Jan 2016	With similar-sized White-eyed Parakeets. Some adults with extensive red on face. Juveniles with red foreheads.
Miller Drive Roost (Brewer Park)	Miami-Dade	26 Apr 2016	A number of birds were noted under the canopy of a thicket of trees, some engaging in mating behavior. They were medium-sized parrots with bright cherry-red faces, the color completely encircling their white-ringed eyes. Their bills were pale-colored. The bend in the wing had red markings, but there was no red flecking in the rest of the plumage. There was a hint of blue in the primaries and the upper tail feathers, and the undertail exhibited yellow. They had a recognizable parrot chatter that drew attention to them.
Miller Drive Roost (Brewer Park)	Miami-Dade	27 Apr 2016	Large, long-tailed parakeets with cleanly marked red faces and red at the bend of the wings. Associating with crevices in Casuarina sp -- nesting here!
Fuchs Park	Miami-Dade	29 Jun 2016	Two birds at nest hole in dead palm. Completely red head extending from cap to below chin. Red leading edge on wings.
Miller Drive Roost (Brewer Park)	Miami-Dade	17 Jan 2017	Took photo of group of three birds, apparently two adults and juvenile. Red coloring on head matches description of red-masked--more complete/extensive than Mitred. Also photo shows red on "shoulder" characteristic of Red-Masked. There were at least 7 other parakeets in same group but not able to confirm identity.

^aData sources: ‡ = Diamond and Ross (2019); * = personal observations by S. Epps, L. Manfredi, and D. Click; † = Pranty and Epps 2002; all other records from eBird Basic Dataset (2019).

Table 2. (Continued) Location of Red-masked Parakeet nesting records in Florida from 1997 to 2019 and literature sources.

Locality	County	Date	Comments ^a
Coral Gables	Miami-Dade	6 Jun 2017	‡
Richardson Historic Park and Nature Preserve	Broward	4 Aug 2017	
Terramar	Broward	14 Feb 2018	Juveniles
Pine tree park	Miami-Dade	15 Mar 2018	Some seemed to be red masked/white eyed hybrids but two appeared clean with clear red mask slight flecking on body, mostly yellow green underwing. Working figs with large flock.
Utopia	Miami-Dade	17 Mar 2018	Full red mask with red leading edge and yellow/orange underwings. Investigating nesting site.
South Miami	Miami-Dade	8 Jun 2018	‡
Olympia Heights	Miami-Dade	17 Jun 2018	‡
Miami Springs	Miami-Dade	29 Jun 2018	Allopreening on a powerline; an adult and what I presume was a juvenile. The adult showed classic plumage, with bright red on the head surrounding the wide white orbital rings, and with red and yellow at the shoulders. The juvenile was entirely green with wide whitish orbital rings.
Biltmore Hotel	Miami-Dade	16 Feb 2019	Significant group nesting in the uppermost eaves of the Biltmore hotel. Photos show red head with clean borders.
Richardson Historic Park and Nature Preserve	Broward	7 Mar 2019	Possibly nesting - seen going in & out of tree cavity.
Biltmore Hotel	Miami-Dade	11 Mar 2019	Nesting in the eye cavities. Large amount of red on forehead, face, and head.
Miller Drive Roost (Brewer Park)	Miami-Dade	20 Mar 2019	Attractive red mask around eyes. Known roost/breeding site
Biltmore Hotel	Miami-Dade	16 Apr 2019	Completely red on the forehead and cheeks of the bird. Seen flying off and onto some nests.

^aData sources: ‡ = Diamond and Ross (2019); * = personal observations by S. Epps, L. Manfredi, and D. Click; † = Pranty and Epps 2002; all other records from eBird Basic Dataset (2019).

uncorrected CBC count data because of the lack of a significant difference between the pooled CBC counts and those of single observations.

Post hoc analysis.—The Red-masked Parakeet's population has shown a trend toward a stable equilibrium since 2004 with a decrease in interannual variation over time (Fig. 2). From 2004 to 2010, the population showed a pattern of irregular oscillations, with a coefficient of variation (CV) of 60.2% and an average of 256 ± 154 (SD) individuals. Since 2011, the population has shown a marked stabilization with a CV of 22.8% and an average of 149 ± 34 (SD) individuals. The pre and post-2011 variance in the populations were unequal ($F = 20.15$, $P < 0.001$). Descriptively, the overall relationship between population and year from 1989 to 2018 was a logistic-regression-type curve (Fig. 3), demonstrating slow initial growth followed by a rapid increase and a plateau in population size.

DISCUSSION

Runde et al. (2007) concluded that the Red-masked Parakeet population in south Florida expanded during the period 1989–2006. Our analysis of recent data indicates that the population is no longer increasing. The pattern of slow population growth followed by rapid expansion and then a plateau (Fig. 2) is similar to Fraticelli's (2004) findings on stable Rose-ringed Parakeet (*Psittacula krameri*) populations in Rome, Italy and consistent with a common pattern of establishment in invasive species (Shigesada and Kawasaki 1997).

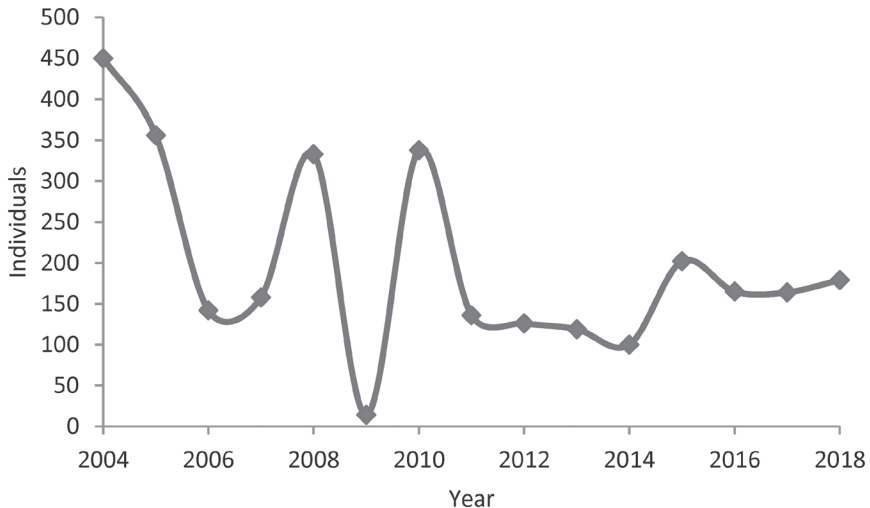


Figure 2. Red-masked Parakeets counted during the Christmas Bird Count in Dade County, Fort Lauderdale, and Kendall, Florida, uncorrected for effort.

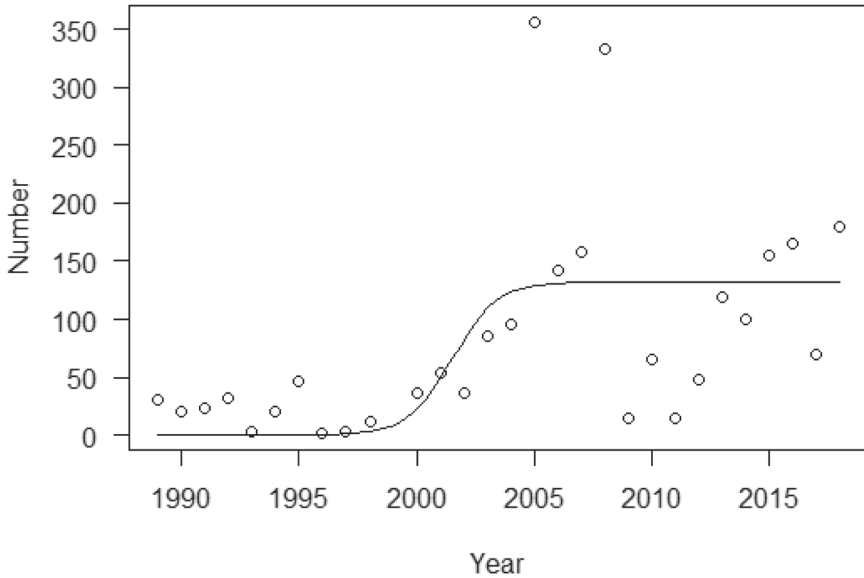


Figure 3. Christmas Bird Counts of Red-masked Parakeets in Dade County, Fort Lauderdale, and Kendall, Florida over time with a fitted, continuous logistic curve. The curve illustrates the distinct trend of slow population growth followed by rapid expansion and then a gradual stabilization characteristic of an established species.

The 450 individuals counted on the 2004 CBCs included 355 from the Las Olas area in the Fort Lauderdale circle, representing the peak of Red-masked Parakeet numbers reported in Florida (S. Epps. unpublished data). In 2011, the roosting trees in the Las Olas area were cut down (L. Manfredi, pers. comm.) and may have played a part in the sharp decrease seen in population counts by dispersing a major flock. The second author observed a similar phenomenon when another roosting site was destroyed, and several smaller roosts formed in the vicinity. Geographic dispersion into smaller groups may explain the significantly lower inter-annual population counts observed post-2011 by reducing skew (if present) in the reports used to compile CBCs. This is unlikely to be a permanent trend given the gregarious nature of the species noted by Best et al. (1995) and may result in a return to high inter-annual variance in count numbers.

In the last 8 years, eBird and CBCs consistently report Red-masked Parakeet counts at approximately half the pre-2011 levels. Population trends are largely dependent on breeding success, though escapees may play a partial but unknown role because of their popularity as pets (Best et al. 1995). Pranty and Epps (2002) noted as early as 2001 that Red-masked Parakeets were successfully breeding in Broward

County and the population was increasing. Diamond and Ross (2019) concluded that Red-masked Parakeets were one of the two most successful cavity nesting parrots in the Miami area. Thus the observed data could indicate a trend towards population stability or a temporary plateau leading to a future increase.

We conclude that the pattern exhibited by Red-masked Parakeets since their first report in 1986 follows that of an established exotic species (Shigesada and Kawasaki 1997), but we suggest more can be done to explicitly monitor their population going forward. Garrett (2018) reports that parrots require special techniques not regularly employed in Florida, such as morning roost departure surveys. Advocating such methods in conjunction with tracking known roosting locations will help further our understanding of this species in south Florida.

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