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## THE NON-MARINE HERPETOFAUNA OF KEY BISCAIYNE, FLORIDA

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**Abstract.**—Key Biscayne is the southernmost sand barrier island along Florida's Atlantic coastline located just offshore of Miami, Miami-Dade County, Florida. Although Key Biscayne's terrestrial fauna is poorly documented, the island has a reputation for being home to a variety of amphibians and reptiles. Herein, we provide historical land use information for Key Biscayne, along with both previous (before 1998) and current (2000–2006) records of the non-marine herpetofauna found on the island, including Bill Baggs Cape Florida State Park (BBCF), Crandon Park (CP), and the Village of Key Biscayne. Although there are no known previous records of amphibians on Key Biscayne before our study in 2000, we documented 29 reptiles recorded or observed between 1951–1998, including 12 turtles (five native, seven nonindigenous), at least 11 lizards (one native, 10 nonindigenous), five snakes (four native, two nonindigenous), and one nonindigenous crocodile. Our field surveys from 2000 through 2006 yielded eight amphibians (five native and three nonindigenous) and at least 37 reptiles, including at least nine turtles (six native, three nonindigenous), at least 19 lizards (four native, 15 nonindigenous), and nine snakes (seven native, two nonindigenous). This totals 7,168 individuals, including 2,186 from BBCF and 4,982 from CP. The 57 amphibian and reptile taxa we documented to occur on KB at one time or another ranks it as the third most diverse area in all of southern Florida, but its relatively small size (919 ha) makes it unique in that one does not have to survey large areas to find a variety of herpetofaunal species.

**Key Words.**—amphibian; Bill Baggs Cape Florida State Park; Crandon Park; exotic; introduced; Miami-Dade County, nonindigenous; reptile

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### INTRODUCTION

The barrier island of Key Biscayne, located just offshore of Miami, Miami-Dade County, Florida, attracts over one million visitors each year; it is home to more than 10,000 residents, but more than 60% of the island is uninhabited and confined within two protected areas: Bill Baggs Cape Florida State Park (BBCF) and Crandon Park (CP) (Village of Key Biscayne 2008. Available from <http://www.keybiscayne.fl.gov> [Accessed 10 August 2008]). Key Biscayne contains a variety of subtropical habitats, including beaches, dunes, mangroves, coastal grasslands, and hardwood hammocks. Although Key Biscayne's terrestrial fauna is poorly documented, the island has a reputation for being inhabited by a variety of introduced amphibians and reptiles (King and Krakauer 1966; Krysko et al. 2006, 2007, 2009).

Florida currently has more introduced herpetofaunal species than any other state (Meshaka et al. 2004b). Most of these species occur in southern Florida, the region south of the northern shore of Lake Okeechobee

to the Florida Keys. Herein, we provide historical land use information for Key Biscayne, along with previous (before 1998) and current (2000–2006) records of the non-marine herpetofauna found on the island.

### MATERIALS AND METHODS

**Study sites and history.**—Key Biscayne (25.696072°N, -80.162087°W) is the southernmost sand barrier island along Florida's Atlantic coastline (Hoffmeister 1974). It is 7.0 km long and up to 2.3 km wide, encompasses approximately 919 ha, and is situated 5.6 km from the mainland south of Miami Beach, where it is connected by the Rickenbacker Causeway to the mainland via Virginia Key (Fig. 1). Its low bedrock of ancient coral reef rock is covered with wave-deposited sand and material dredged from Biscayne Bay in the 1950s (Hoffmeister 1974). The central part of the island contains the 360-ha Village of Key Biscayne (VKB), which had a 2000 population of 10,507 persons living in 6,318 residences, about 80% of which were condominiums (Village of Key Biscayne 2008. *op. cit.*).

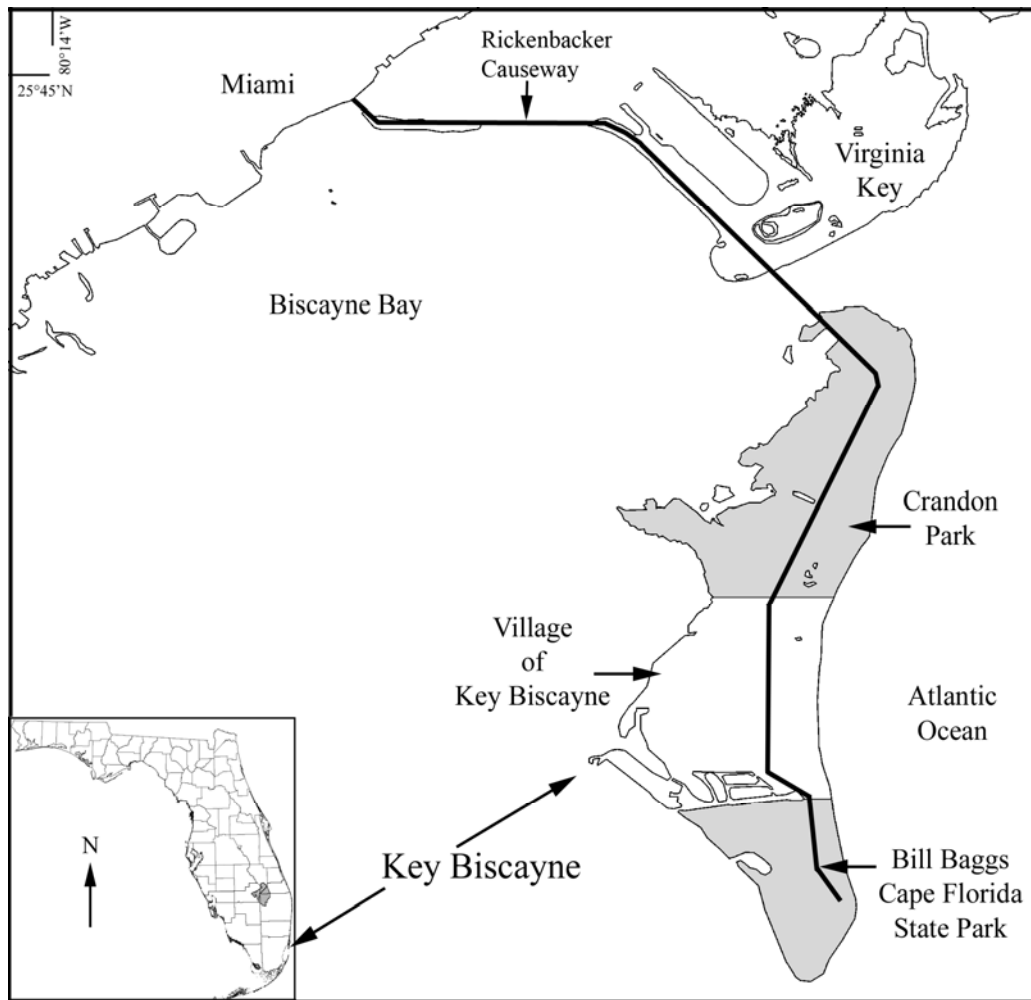


FIGURE 1. Map of our study sites on Key Biscayne, Miami-Dade County, Florida.

All natural habitats on Key Biscayne are found in both BBCF and CP.

Bill Baggs Cape Florida State Park (25.673667°N, -80.1575°W) occupies the southern one-quarter of Key Biscayne (Fig. 1) and contains 174-ha of upland (131-ha) and submerged (43-ha) habitats including tidal wetlands. On its eastern shoreline, 2 km of natural beach and dunes border the Atlantic Ocean; the park's southern and western shorelines consist of a seawall. Much of the original sand and peat soils were buried under 0.2–1.4 m of marl fill dredged from Biscayne Bay for development by previous owners in 1949–1950 (Blank 1996). This dredge-and-fill operation converted the natural dune-and-swale topography to a relatively flat landscape with uplands typically 1.5–2.1 m above sea level. Subsequently, from the early 1950s to early 1990s, vegetation consisted primarily of weedy and invasive nonindigenous species, although areas of native coastal vegetation existed along the eastern shoreline (Division of Recreation and Parks 2001). A mature, nonindigenous Australian Pine (*Casuarina equisetifolia*)

forest dominated the site when the Florida Park Service acquired the property in the late 1960s (Division of Recreation and Parks 2001). After Hurricane Andrew destroyed the *Casuarina* forest in August 1992, park staff began to restore the original native plant communities. Presently, 28-ha of mangrove forest has been restored since previous filling operations and seawall construction eliminated the original channels and forest, and 2-ha of interdunal swale ponds have been restored adding to the preexisting 1-ha of ponds and ditches. Maritime hammock has been created on 36-ha, and coastal strand vegetation is being planted on 62-ha. Additionally, 8-ha of intact beach dune and coastal grassland habitat are being maintained.

Crandon Park (25.704317°N, -80.157883°W) occupies 385-ha on the northern half of Key Biscayne (Fig. 1). Crandon Park was donated to Miami-Dade County in 1940 by the well-known Matheson family (Blank 1996), who owned a large coconut plantation there. In 1948, the truck of a traveling animal show from New Mexico broke down on U.S. 41 (Tamiami Trail), and in payment

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**TABLE 1.** Previous records and observations from 1951 through 1998 of the non-marine herpetofauna from Key Biscayne, Miami-Dade County, Florida. Note that an asterisk next to a scientific name indicates a nonindigenous species; under location, KB = Key Biscayne (no specific locality known), BBCF = Bill Baggs Cape Florida State Park, CP = Crandon Park, and VKB = Village of Key Biscayne. Source acronyms follow Leviton et al. (1985), with the addition of Everglades National Park (EVER) whose entire collection is now accessioned into the University of Florida.

Species	Common Name	Location	Date	Source
<b>Testudines</b>				
<i>Apalone ferox</i>	Florida Softshell	CP	1976	Bader (1976)
<i>Chelus fimbriatus</i> *	Mata Mata Turtle	CP	1985	Ron St. Pierre (pers. comm.)
<i>Chelydra serpentina</i>	Snapping Turtle	CP	1976	Bader (1976)
<i>Graptemys flavimaculata</i> *	Yellow-blotched Map Turtle	CP	1976	Bader (1976)
<i>Kinosternon baurii</i>	Striped Mud Turtle	KB		Duellman and Schwartz (1958)
<i>Podocnemis unifilis</i> *	Yellow-spotted River Turtle	CP	1976	Bader (1976)
<i>Pseudemys nelsoni</i>	Florida Red-bellied Cooter	CP	1976	Bader (1976)
		CP	1 Apr 1984	UF 55874-75
<i>Pseudemys peninsularis</i>	Peninsula Cooter	CP	1976	Bader (1976)
<i>Trachemys ornata</i> *	Ornate Slider	CP	1976	Bader (1976)
<i>Trachemys scripta elegans</i> *	Red-eared Slider	CP	1976	Bader (1976)
<i>Trachemys scripta scripta</i> *	Yellow-bellied Slider	CP	1976	Bader (1976)
<i>Trachemys terrapen</i> *	Jamaican Slider	CP	1976	Bader (1976)
<b>Sauria</b>				
<i>Ameiva ameiva</i> *	Giant Ameiva	CP		Wilson and Porras (1983)
<i>Anolis carolinensis/porcatus</i>	Green/Cuban Green Anole	CP	30 Aug 1977	UF 102187
<i>Anolis cristatellus</i> *	Puerto Rican Crested Anole	KB	1975	Schwartz and Thomas (1975)
		KB	Sep 1977	UF 121722-24, 121767
		VKB	1977	Brach (1977)
		CP	1 Apr 1984	UF 141842-43
		CP		Wilson and Porras (1983)
<i>Anolis distichus</i> *	Bark Anole	CP	16 Aug 1963	UF 85402-03
<i>Anolis sagrei</i> *	Brown Anole	KB	8 Sep 1967	CAS 111007-08
		KB	Sep 1977	UF 121768
		CP	1 Apr 1984	UF 141844
<i>Ctenosaura similis</i> *	Gray's Spiny-tailed Iguana	CP	15 Sep 1996	EVER 304105
		CP	Feb 1997	EVER 306532
<i>Hemidactylus garnotii</i> *	Indo-Pacific House Gecko	CP	20 Jan 1967	UF 90662
<i>Iguana iguana</i> *	Green Iguana	CP		Wilson and Porras (1983)
<i>Leiocephalus carinatus</i> *	Northern Curly-tailed Lizard	CP		King and Krakauer (1966)
		CP	6 May 1967	UF 84606
<i>Varanus exanthematicus</i> *	Savannah Monitor	BBCF	7 Feb 1995	Elizabeth A. Golden (pers. comm.)
<i>Varanus salvator</i> *	Water Monitor	CP	1998	Ron St. Pierre (pers. comm.)
<b>Serpentes</b>				
<i>Coluber constrictor</i>	North American Racer	CP	28 Nov 1951	UF 114213
<i>Crotalus adamanteus</i>	Eastern Diamond-backed Rattlesnake	KB	1915	William Evans Thomas (unpubl. data)
		KB		Blank (1996)
<i>Masticophis flagellum</i>	Eastern Coachwhip	KB		Duellman and Schwartz (1958)
<i>Nerodia fasciata</i>	Southern Watersnake	VKB	13 Sep 1960	UF 88492
<i>Ramphotyphlops braminus</i> *	Brahminy Blindsnake	CP	17 Feb 1997	EVER 305854
<b>Crocodylia</b>				
<i>Mecistops cataphractus</i> *	African Slender-snouted Crocodile	CP	1993	Joe Wasilewski (pers. comm.)

for repairs and traveling money, the show gave the county some animals (Barnes 1986). Two black bears and two gray monkeys were transferred to CP to increase its attendance, necessitating the construction of enclosures and cages, resulting in the creation of the Crandon Park Zoo in 1949 (Barnes 1986). In 1965, storm surge from Hurricane Betsy flooded nearly all of Key Biscayne, killing approximately 250 zoo animals (Ernie Lynk, pers. comm.). At one time, as many as 1,200 animals were on display at the zoo, until it closed

in 1979 when their animals were transferred to the newly built Miami MetroZoo on the mainland (Ernie Lynk, pers. comm.). Crandon Park presently contains a nature center, tennis center, golf course, marina, family amusement park, beaches, other recreation areas, and botanical garden (i.e., Crandon Gardens). In particular, Crandon Gardens is a 15-ha section that includes remnants of the former Matheson family's large coconut plantation, old CP Zoo exhibits, trails, landscaped vegetation, brackish water ponds, and landlocked canals

that wind through a tidal mangrove swamps and hardwoods.

**Records.**—We obtained previous non-marine herpetofaunal records for Key Biscayne from both the literature and preserved specimens in systematic collections throughout the United States (Table 1). Source acronyms follow Leviton et al. (1985), with the addition of Everglades National Park (EVER), whose entire collection is now accessioned into UF. Although we are excluding marine herpetofauna in this study, the American Crocodile (*Crocodylus acutus*) and both Loggerhead (*Caretta caretta*) and Leatherback (*Dermochelys coriacea*) sea turtles have been observed on Key Biscayne (Donlan et al. 2004). Information on species previously housed at the old CP Zoo was obtained from the Miami MetroZoo database (Steve Conners, pers. comm.), which assisted us in determining how certain species might have been originally introduced onto Key Biscayne.

Our current records from BBCF are based mainly on opportunistic collections during daily park staff work conducted by two of us (EMD and EAG) from December 2000 through December 2005. Our current records at CP are based on captures and observations made during 19 survey days from December 2000 through July 2006. Captures at both parks were made by hand and with nooses, fishing rods with barbless hooks using domestic crickets for bait (Krysko 2000), baited hoop traps (Lagler et al. 1943), noose carpets or Bal Chatri traps, and blowguns shooting tapered corks (Krysko et al. 2009).

Scientific and common names mostly follow Crother (2008). Because of the difficulty in distinguishing the native Green Anole (*Anolis carolinensis*) from the nonindigenous Cuban Green Anole (*A. porcatus*) using morphology, we have combined these two species throughout the text as *A. carolinensis/porcatus* and noted it as being native. Voucher specimens and photographs were deposited in Cornell University Veterinary Anatomy (CUVETA); East Tennessee State University–Comparative Collection (ETMNH-CC); Florida Museum of Natural History, University of Florida (UF); Indiana State University–Vertebrate Collection (ISUVC); National Museum of Natural History (USNM); and Yale Peabody Museum (YPM).

## RESULTS

Although there are no known previous records of amphibians on Key Biscayne before our study in 2000, we documented 29 reptiles recorded or observed between 1951 and 1998 (Table 1), including 12 turtles (five native, seven nonindigenous), at least 11 lizards (one native, 10 nonindigenous), five snakes (four native, two nonindigenous), and one nonindigenous crocodile.

Three of these reptiles were found at a general KB locality only, one was found in VKB only, two were found at BBCF only, 22 were found at CP only, and two were found at both a general KB locality and in CP.

Our field surveys from 2000 through 2006 yielded eight amphibians (five native and three nonindigenous) and at least 37 reptiles (Table 2), including at least nine turtles (six native, three nonindigenous), at least 19 lizards (four native, 15 nonindigenous), and nine snakes (seven native, two nonindigenous). There was a total of 7,168 individuals, including 2,186 from BBCF and 4,982 from CP. Fifteen of these species were found at BBCF only, seven were found at CP only, and the remaining 23 were found at both BBCF and CP.

## DISCUSSION

Southern Florida is considered to have a low herpetofaunal species richness compared to the Florida panhandle (Kiestler 1971; Iverson 1992; Duellman and Sweet 1999). Means and Simberloff (1987) believed that this paucity was due to less habitat diversity in the southern peninsula and Florida Keys than in areas to the north. Nonetheless, Duellman and Schwartz (1958) recorded 79 currently recognized non-marine herpetofaunal species (excluding *Plestiodon laticeps* [erroneous identification]) from the entire southern Florida region, including 21 amphibians (18 native, three nonindigenous) and 58 reptiles (50 native, eight nonindigenous), 65 of which were recorded from Miami-Dade County (Duellman and Schwartz 1958). Dalrymple (1988) recorded 51 non-marine herpetofaunal species from the 8,000-ha Long Pine Key within Everglades National Park (ENP), Miami-Dade County, including 15 amphibians (13 native, two nonindigenous) and 36 reptiles (35 native, one nonindigenous). Meshaka et al. (2000) recorded 61 non-marine herpetofaunal species from the entire 610,000-ha ENP consisting of both Miami-Dade and Monroe counties, including 16 amphibians (14 native, two nonindigenous) and 45 reptiles (39 native, six nonindigenous). O'Hare and Dalrymple (1997) recorded 43 non-marine herpetofaunal species from the 19,400-ha Lake Belt Study Area in the southern Everglades of northern Miami-Dade County, including 16 amphibians (15 native, one nonindigenous) and 27 reptiles (26 native, one nonindigenous). Meshaka (1999a) recorded 17 non-marine herpetofaunal species from a 4-ha tropical garden (The Kampong) along the western edge of Biscayne Bay, Miami-Dade County, including three amphibians (all nonindigenous) and 14 reptiles (five native, nine nonindigenous). Meshaka (1999b) recorded 13 non-marine herpetofaunal species from the 1.2-ha Doc Thomas House in Miami, Miami-Dade County, including three amphibians (all nonindigenous) and 10 reptiles (three native, seven nonindigenous). Meshaka et

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**TABLE 2.** Non-marine amphibians and reptiles recorded from Bill Baggs Cape Florida State Park (BBCF) and Crandon Park (CP) on Key Biscayne, Miami-Dade County, Florida, from December 2000 through December 2006. Numbers represent individual observations, likely including multiple sightings of the same animals on different dates; thus, they could not be a direct measure of population size. An asterisk next to scientific name indicates a nonindigenous species.

Species	Common Name	BBCF	CP	Total
<b>Anura</b>				
<i>Anaxyrus terrestris</i>	Southern Toad	10	0	10
<i>Eleutherodactylus planirostris</i> *	Greenhouse Frog	17	3	20
<i>Gastrophryne carolinensis</i>	Eastern Narrow-mouthed Toad	26	0	26
<i>Hyla cinerea</i>	Green Treefrog	1	20	21
<i>Hyla squirella</i>	Squirrel Treefrog	19	10	29
<i>Lithobates sphenoccephalus</i>	Southern Leopard Frog	11	0	11
<i>Osteopilus septentrionalis</i> *	Cuban Treefrog	53	1	54
<i>Rhinella marina</i> *	Cane Toad	1	511	512
	<b>Total</b>	<b>138</b>	<b>545</b>	<b>683</b>
<b>Testudines</b>				
<i>Apalone ferox</i>	Florida Softshell	1	55	56
<i>Chelydra serpentina</i>	Snapping Turtle	0	4	4
<i>Gopherus polyphemus</i>	Gopher Tortoise	1	0	1
<i>Kinosternon</i> sp.	Mud Turtle	1	0	1
<i>Pseudemys nelsoni</i>	Florida Red-bellied Cooter	4	2	6
<i>Pseudemys</i> sp.	Cooter	0	22	22
<i>Terrapene carolina</i>	Eastern Box Turtle	12	0	12
<i>Testudo horsfieldii</i> *	Russian Tortoise	1	0	1
<i>Trachemys scripta elegans</i> *	Red-eared Slider	6	32	38
<i>Trachemys scripta scripta</i> *	Yellow-bellied Slider	1	0	1
	<b>Total</b>	<b>27</b>	<b>115</b>	<b>142</b>
<b>Sauria</b>				
<i>Ameiva ameiva</i> *	Giant Ameiva	28	56	84
<i>Anolis carolinensis/porcatus</i>	Green/Cuban Green Anole	7	27	34
<i>Anolis cristatellus</i> *	Puerto Rican Crested Anole	0	638	638
<i>Anolis distichus</i> *	Bark Anole	101	331	432
<i>Anolis equestris</i> *	Knight Anole	7	8	15
<i>Anolis sagrei</i> *	Brown Anole	158	670	828
<i>Aspidoscelis sexlineata</i>	Six-lined Racerunner	16	0	16
<i>Basiliscus vittatus</i> *	Brown Basilisk	7	129	136
<i>Ctenosaura similis</i> *	Gray's Spiny-tailed Iguana	24	428	452
<i>Hemidactylus garnotii</i> *	Indo-Pacific House Gecko	2	0	2
<i>Hemidactylus mabouia</i> *	Wood Slave	53	30	83
<i>Hemidactylus</i> sp.*	Hemidactyline Gecko	12	22	34
<i>Iguana iguana</i> *	Green Iguana	1474	1956	3430
<i>Leiocephalus personatus</i> *	Haitian Curly-tailed Lizard	0	4	4
<i>Plestiodon inexpectatus</i>	Southeastern Five-lined Skink	4	0	4
<i>Pseudocordylus microlepidotus</i> *	Cape Crag Lizard	0	1	1
<i>Sphaerodactylus notatus</i>	Florida Reef Gecko	5	2	7
<i>Tupinambis teguixin</i> *	Golden Tegu	0	1	1
<i>Uranoscodon superciliosus</i> *	Diving Lizard	0	1	1
<i>Varanus exanthematicus</i> *	Savannah Monitor	1	0	1
	<b>Total</b>	<b>1899</b>	<b>4304</b>	<b>6203</b>

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al. (2008) reported 18 non-marine herpetofaunal species from The Barnacle Historic State Park (3.6 ha) in Miami, Miami-Dade County, including one nonindigenous amphibian and 17 reptiles (eight native, nine nonindigenous). Lastly, Rice et al. (2007) recorded 13 non-marine herpetofaunal species on four small (total 1,110 ha) islands (Boca Chita Key, Sands Key, Elliott Key, and Old Rhodes Key) in Biscayne National Park, Miami-Dade County, including five amphibians (two native, three nonindigenous) and eight reptiles (five native, three nonindigenous). Therefore, it would not be unreasonable to believe that the relatively small 919-ha

island of KB, which contains mostly human-modified habitats, would also have a relatively low diversity of herpetofauna. However, we documented a total of at least 57 non-marine herpetofaunal species (8 amphibians [five native, three nonindigenous] and 49 reptiles [20 native, 29 nonindigenous]) on KB from 1951 to 2006 (Tables 1–2), including eight frogs (five native, three nonindigenous), 15 turtles (seven native, eight nonindigenous), 22 lizards (four native, 18 nonindigenous), 11 snakes (nine native, two nonindigenous), and one nonindigenous crocodile. The deceptively high degree

**TABLE 2.** *Continued.* Non-marine amphibians and reptiles recorded from Bill Baggs Cape Florida State Park (BBCF) and Crandon Park (CP) on Key Biscayne, Miami-Dade County, Florida, from December 2000 through December 2006. Numbers represent individual observations, likely including multiple sightings of the same animals on different dates; thus, they could not be a direct measure of population size. An asterisk next to scientific name indicates a nonindigenous species.

Species	Common Name	BBCF	CP	Total
<b>Serpentes</b>				
<i>Boa constrictor*</i>	Boa Constrictor	1	0	1
<i>Coluber constrictor</i>	North American Racer	33	7	40
<i>Diadophis punctatus</i>	Ring-necked Snake	13	2	15
<i>Lampropeltis elapsoides</i>	Scarlet Kingsnake	7	0	7
<i>Nerodia fasciata</i>	Southern Watersnake	0	3	3
<i>Pantherophis alleghaniensis</i>	Eastern Ratsnake	22	0	23
<i>Pantherophis guttatus</i>	Red Cornsnake	21	1	22
<i>Ramphotyphlops braminus*</i>	Brahminy Blindsnake	20	3	23
<i>Thamnophis sauritus</i>	Eastern Ribbonsnake	2	2	4
	Total	123	18	141
	Grand Total	2,186	4,982	7,168

of herpetofaunal diversity on KB is because of the presence of ever-increasing numbers of nonindigenous species in the pet trade.

In 1958, only 12 nonindigenous herpetofaunal species were documented in all of southern Florida: Cane Toad (*Rhinella marina*), Greenhouse Frog (*Eleutherodactylus planirostris*), Cuban Treefrog (*Osteopilus septentrionalis*), Giant Ameiva (*Ameiva ameiva*), Bark Anole (*Anolis distichus*), Knight Anole (*A. equestris*), Brown Anole (*A. sagrei*), Yellow-headed Gecko (*Gonatodes albogularis*), Mediterranean Gecko (*Hemidactylus turcicus*), Northern Curly-tailed Lizard (*Leiocephalus carinatus*) (erroneously stated as exterminated; Duellman and Schwartz, 1958:284), Ocellated Gecko (*Sphaerodactylus argus*), and Ashy Gecko (*S. elegans*) (Duellman and Schwartz 1958; Neill 1957). Today, there are at least 47 nonindigenous herpetofaunal species, mostly tropical lizards, now established in southern Florida (KLK pers. obs.; Meshaka et al. 2004b; Krysko and Daniels 2005; Krysko and Enge 2005). The proliferation of nonindigenous species is partly because of Florida's subtropical climate, variety of microhabitats, and thriving pet trade (Wilson and Porras 1983; Dalrymple 1988; Simberloff 1997; Enge et al. 2004; Meshaka et al. 2004b), but a more important factor may be the drastic habitat alteration that has occurred over the last century, creating numerous vacant niches and facilitating the invasion of nonindigenous species. Although animals that escaped from their enclosures at the old CP Zoo were likely the origin of some nonindigenous species found on KB today, not all escapees became established; a single African Slender-snouted Crocodile (*Crocodylus cataphractus*) that was displayed at the old CP Zoo was captured there in 1993 (14 years after the zoo closed) by Joe Wasilewski (pers. comm.). However, most nonindigenous species on KB are likely directly related to intentional and illegal releases by pet owners for decades; both former CP Zoo and current CP staff have observed visitors releasing their unwanted pets there (Ernie Lynk and Steve Conners, pers. comm.).

Although no amphibians were previously reported from KB, we found eight anuran species (Table 2). We recorded all eight anuran species at BBCF but did not find the native Southern Toad (*Anaxyrus terrestris*), Eastern Narrow-mouthed Toad (*Gastrophryne carolinensis*), nor Southern Leopard Frog (*Lithobates sphenoccephalus*) at CP, possibly because of the presence of more intact natural habitats in BBCF.

Twelve non-marine turtle taxa were previously reported from KB (Table 1), and we found at least nine turtles (Table 2). We consider at least five of these species to be established on KB, including the native Florida Softshell (*Apalone ferox*), Snapping Turtle (*Chelydra serpentina*), Florida Red-bellied Cooter (*Pseudemys nelsoni*), and Eastern Box Turtle (*Terrapene carolina*), and the nonindigenous Red-eared Slider (*Trachemys scripta elegans*). A sixth species, *Kinosternon baurii*, was first reported on KB by Duellman and Schwartz (1958), and in October 1999, BBCF park staff found and photographed a *Kinosternon* from an upland area at the southern end of the park near an extensive brackish-water ditch system. Because the photographs are blurry and we know that there have been introductions of nonindigenous mud turtles on the nearby mainland in Miami, we could not definitively identify it as a native *K. baurii*. The population of nonindigenous *T. s. elegans* on KB has been present for more than 40 years (King and Krakauer 1966), and in one night on 5 May 2006 at CP, we captured 28 adult *T. s. elegans*, five *Apalone ferox*, and two *Chelydra serpentina* in 12 hoop traps (Enge et al. 2007). Bader (1976) reported collecting numerous turtles at CP, including the native *Apalone ferox*, *Chelydra serpentina*, *Pseudemys nelsoni*, and Peninsula Cooter (*P. peninsularis*), and the nonindigenous Yellow-blotched Map Turtle (*Graptemys flavimaculata*), *Trachemys scripta elegans*, *T. s. scripta*, Ornate Slider (*T. ornata*), Jamaican Slider (*T. terrapen*), and Yellow-spotted River Turtle (*Podocnemis unifilis*). Ron St. Pierre (pers. comm.) captured a Matamata Turtle (*Chelus fimbriatus*)

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**TABLE 3.** Summary of non-marine herpetofaunal studies conducted in southern Florida, organized by study site size.

Location	Area (ha)	#Species	Amphibians	Reptiles	Source
Southern Florida	3,126,764	79	21	58	Duellman and Schwartz (1958)
Everglades National Park	610,000	61	16	45	Meshaka et al. (2000)
Lake Belt Study Area	19,400	43	16	27	O'Hare and Dalrymple (1997)
Everglades National Park; Long Pine Key	8,000	51	15	36	Dalrymple (1988)
Biscayne National Park; Boca Chita, Sands, Elliott, and Old Rhodes keys	1,110	13	5	8	Rice et al. (2007)
Key Biscayne	919	57	8	49	<i>This study</i>
The Kampong	4	17	3	14	Meshaka (1999a)
The Barnacle Historic State Park	3.6	18	1	17	Meshaka et al. (2008)
Doc Thomas House	1.2	13	3	10	Meshaka (1999b)

at CP ca. 1985. Some of the 22 Cooters (*Pseudemys* sp.; Table 2) we observed from a distance at CP could have been *P. peninsularis*. However, we did not find any of the other species nor could we locate any voucher specimens or photographs of these captured turtles; thus, if they were introduced, they appear to have been extirpated. Additionally, *G. polyphemus*, *T. horsfieldii*, and *T. s. scripta* appear to be individual releases and are not established.

Eleven lizard species were previously reported on KB (Table 1), and we found at least 19 lizard species (Table 2). We consider at least 13 of these species to be established on KB, including the native Green Anole (*Anolis carolinensis/porcatus*), Six-lined Racerunner (*Aspidoscelis sexlineata*), Southeastern Five-lined Skink (*Plestiodon inexpectatus*), and Florida Reef Gecko (*Sphaerodactylus notatus*), and the nonindigenous *Ameiva ameiva*, Puerto Rican Crested Anole (*Anolis cristatellus*), *A. distichus*, *A. equestris*, *A. sagrei*, Brown Basilisk (*Basiliscus vittatus*), Gray's Spiny-tailed Iguana (*Ctenosaura similis*), Wood Slave (*Hemidactylus mabouia*), and Green iguana (*Iguana iguana*). All four of the native lizards were found at BBCF, whereas only two were found at CP. In contrast, 13 of the 15 nonindigenous lizards were found at CP, whereas only 10 were found at BBCF. *Ameiva ameiva* is a common species on KB, and on 12 September 2006 at BBCF, we observed an adult preying upon a Black and White Warbler (*Mniotilta varia*) trapped in a mist net. *Ctenosaura similis* is thriving on KB, and at CP, the largest readily observable colony occupies a large pile of limerock boulders that was once part of the goat exhibit at the old CP Zoo. Burrows are present under many large rocks and concrete slabs throughout CP, and some individuals use large, buried PVC pipes or burrows at the edges of ponds, sometimes sharing them with *Iguana iguana*.

King and Krakauer (1966) first reported *Iguana iguana* in Florida as nonbreeding; however, the population on KB has increased exponentially since Hurricane Andrew in 1992, possibly because of the more open canopy, subsequent replanting of landscape vegetation favored as food by iguanas, and creation of suitable nesting areas in the form of piles of sand and mulch (Meshaka et al. 2004a; Krysko et al. 2007).

Although *I. iguana* is the largest established nonindigenous lizard on KB and is now common throughout the island, it was not recorded at BBCF until 1997. From 2003 to 2004, EMD was responsible for conducting an eradication program, and 1,216 *I. iguana* were removed from the park. Smith et al. (2007a) used some of these data to estimate a minimum population density of 6.27 individuals/ha, and (Smith et al. 2007b) reported that *I. iguana* and *Coluber constrictor* were the most common road-killed reptile species in BBCF from 1996 through 2006. At CP, *I. iguana* and *Ctenosaura similis* consume cracked corn supplied daily to the nonindigenous waterfowl (Krysko et al. 2009). On 28 February 2002, the overnight air temperature dropped to a low of 8°C, and at 0745 h, KLK and KME started canoeing the lakes and canals, capturing 37 *I. iguana* by hand or noose as they lay motionless on vegetation. In one section of a canal amongst dense Cattails (*Typha* sp.), we observed at least 10 adult *I. iguana* submerged in the warmer water (ca. 20°C) with only their snouts protruding to breathe, allowing them to escape the cold ambient air temperatures and actively avoid capture by submerging completely when approached.

Although some other lizards have been observed on KB over the years, they have been extirpated or there is no evidence of establishment on the island. Tegus (*Tupinambis* sp.) were observed at the old CP Zoo before it closed, sometimes preying upon turtle eggs (Ernie Lynk and Steve Conners, pers. comm.), but we suspect that these might have been *Ameiva ameiva*. Although a single *T. teguixin* was photographed at CP near the end of our study on 21 July 2006, we believe that it was a recent introduction. King and Krakauer (1966) reported Hispaniolan Rhinoceros Iguanas (*Cyclura cornuta cornuta*) had escaped from an exhibit at the Miami Seaquarium on Virginia Key, and this species was frequently observed there and on KB in the 1960s. However, *C. cornuta* apparently never became established on either island, possibly because of harvest by collectors. The nonindigenous Indo-Pacific House Gecko (*Hemidactylus garnotii*) was collected at CP in 1967 (Table 1); however, we did not find this species on KB, and it might have declined or become extirpated as it has from many other areas in southern Florida. King and Krakauer (1966) reported *Leiocephalus carinatus*

*armouri* at both the old CP Zoo and Miami Seaquarium on adjacent Virginia Key and *L. c. coryi* at the old CP Zoo, which were attributed to deliberate releases by CP Zoo staff at that time. Former CP Zoo staff observed *L. carinatus* there (Steve Conners, pers. comm.), and one voucher specimen exists from 1967 (Table 1). However, neither we nor Wilson and Porras (1983) found these species on KB, suggesting they have been extirpated. However, *L. carinatus* still occurs on Virginia Key, and it has expanded its range along the Atlantic Coast of Florida (Smith and Engeman 2004; Smith et al. 2004; Meshaka et al. 2005). On 11 October 2004, we did however find and photograph four Haitian Curly-tailed Lizards (*Leiocephalus personatus*) and a Diving Lizard (*Uranoscodon superciliosus*) at CP, and in September 2006, we photographed a Cape Crag Lizard (*Pseudocordylus microlepidotus*) at CP; these species have not been observed there before nor after these dates, suggesting recent introductions. A single Savannah Monitor (*Varanus exanthematicus*) was found on 7 February 1995 at BBCF. For several years until ca. 1998, a large Water Monitor (*Varanus salvator*) was observed at CP (Ron St. Pierre, pers. comm.). Both of these were likely released pets.

Additionally, we are aware of at least three commercial reptile collectors who have removed many nonindigenous lizards from CP since 2000. During 23 visits to CP from 12 November 2005 through 7 December 2006, one of these collectors removed 1,100 *Iguana iguana*, 162 *Ctenosaura similis*, 20 *Basiliscus vittatus*, 97 *Anolis equestris*, 66 *A. sagrei*, nine *A. cristatellus*, and one *Ameiva ameiva* (George Ward pers. comm.). The other two collectors each reported removing >1,000 *I. iguana*, but exact numbers could not be ascertained.

Five snake species were previously reported from KB (Table 1), and we found nine snakes (Table 2). We consider eight of these species to be established on KB, including the native North American Racer (*Coluber constrictor*), Ring-necked Snake (*Diadophis punctatus*), Scarlet Kingsnake (*Lampropeltis elapsoides*; Harper 2006, Pyron and Burbrink 2009), Southern Watersnake (*Nerodia fasciata*), Eastern Ratsnake (*Pantherophis alleghaniensis*), Red Cornsnake (*Pantherophis guttatus*), and Eastern Ribbonsnake (*Thamnophis sauritus*), and the nonindigenous and parthenogenetic Brahminy Blindsnake (*Ramphotyphlops braminus*). We observed an adult *Coluber constrictor* chasing an *Ameiva ameiva* on 13 March 2003 at CP, and we also salvaged the body of an adult *C. constrictor* that was being eaten by a Red-shouldered Hawk (*Buteo lineatus*) on 29 November 2002. The single Boa Constrictor (*Boa constrictor*) found on 15 Nov 2003 by BBCF park staff was likely a released or escaped pet. Duellman and Schwartz (1958) reported the Eastern Coachwhip (*Masticophis flagellum*) on KB, but we did not find this species. In the

unpublished memoirs of an early KB resident, William Evans Thomas mentioned “rattlesnakes all over the island” in 1915 and additional observations the following few years. Subsequently, Blank (1996:115) mentions rattlesnakes of “seven feet in length” on KB. Both the Pigmy Rattlesnake (*Sistrurus miliarius*) and Eastern Diamond-backed Rattlesnake (*Crotalus adamanteus*) commonly inhabit barrier islands, and one or both of these species likely occurred on Key Biscayne in the past. However, we did not find either rattlesnake species on Key Biscayne, and they possibly have been eliminated by the drastic habitat alteration and human persecution.

Despite some native species declining or apparently becoming extirpated on KB over the years, nonindigenous species have made up for this loss, mostly because of people illegally releasing unwanted pets. The 57 amphibians and reptiles we documented as occurring on KB at some time ranks it as the third most diverse area in all of southern Florida (Table 3), but its relatively small size (919-ha) makes it unique in that one does not have to survey large areas to find a variety of herpetofaunal species.

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#### APPENDIX

Voucher specimens and photographs we recorded from Village of Key Biscayne (VKB), Bill Baggs Cape Florida State Park (BBCF) and Crandon Park (CP) on Key Biscayne, Miami-Dade County, Florida, from December 2000 through December 2006.

- Ameiva ameiva*.—BBCF: UF 133182, 134931, 135491, 135905-06, 137097, 141579, 142905, 143932, 152750-51, USNM 567423, 567425; CP: UF 133830, 134224, 134903, 134929, 135082, 137074, USNM 567424.
- Anolis carolinensis/porcatus*.—BBCF: UF 135965-67; CP: UF 134917, 135981, 144136-38.
- Anolis cristatellus*.—CP: UF 121416, 121450, 130690-92, 130777, 131498-503, 133833-34, 134818-20, 134992-99, 135004-6, 135010-18, 135030-33, 135035-36, 135038-43, 135982, 135984, 135986, 135990, 135998-136004, 141596, 144144-56; USNM 567328-40.
- Anolis distichus*.—BBCF: UF 144164-65; USNM 567351-53; CP: UF 130693-96, 134845, 134947, 135002-03, 135019-21, 135027-29, 135993, 135995-96, 141598, 144141-43; USNM 567347, 567349-50, 567354-56.
- Anolis equestris*.—BBCF: UF 134916, 137714, 145216; CP: UF 144135.
- Anolis sagrei*.—BBCF: UF 134215, 134924-27, 135472-73, 135476, 135968, 144260, USNM 567388; CP: UF 134846-47, 134849, 134918-23, 134928, 135000-01, 135025, 135977, 135988, 135991, 140758, 144130-34; USNM 567380, 567382, 567389-91.
- Anolis* sp.—CP: UF 141570.
- Basiliscus vittatus*.—BBCF: UF 140835; CP: UF 130773, 131505, 131519, 133835-37, 134228-30, 134821, 134904-05, 134911-12, 134914, 137075, 144157-61, 144248, USNM 567393-94.
- Boa constrictor*.—BBCF: UF 155471.
- Coluber constrictor*.—BBCF: UF 135957, 137094, 137718, 140554, 143603, 143940, 149733; CP: UF 135177.
- Ctenosaura similis*.—BBCF: UF 135626, 135947, 138217, 138387, 144234-38, 144242-47, 145215, 147000, 152739, 152744; CP: UF 130697-99, 130772, 130783, 131496-97, 131536, 131543, 133821-28, 134225-27, 134584, 134906, 135047, 135092, 136076, 137073, 144128-29; Village of Key Biscayne: UF 151362.
- Eleutherodactylus planirostris*.—BBCF: UF 134934.
- Gastrophryne carolinensis*.—BBCF: UF 144259.
- Hemidactylus mabouia*.—BBCF: UF 134954-55, 134958-60, 134964, 135474-75, 135477, 135628, 135972, 137713, 140561, 140590, 144162-63; USNM 567285-86; CP: 131506, 131517-18, 134962.
- Hemidactylus* sp.—BBCF: UF 135490; CP: UF 135048-49.
- Iguana iguana*.—BBCF: CUVETA 145238-44, 145263-65, 145269, 145271-77, 145286, 145306-10; ETMNH-CC 418–32; ISUVC 3846-47, 3849 (n=12), 3850 (n=10), 3851-53, 3855-92; UF 134203-10, 134231, 135294, 135470-71, 135486, 135488-89, 135494-500, 135538-52, 135554-60, 135562-63, 135616-22, 135624, 135896, 135907-09, 135911, 135915, 135917-19, 135921-23, 135925-46, 137405, 140564-65, 140581, 140740, 141040-41, 141098, 141101-03, 141109-19, 141220-23, 141225-27, 141230-31, 141233-34, 141236-39, 141248-49, 141487-96, 141498, 141609-10, 141612-17, 141766-68, 141953, 142317, 142333-42, 142344-54, 142551-74, 142591-95, 142625-45, 142647-80, 142722-24, 142731, 142812, 142817-19, 142897-902, 142903-04, 143602, 143607-08, 143946-48, 144310-23, 144343-471, 144575, 145202-14, 145218-237, 145245-62, 145266-68, 145270, 145278-85, 145287-305, 145311-357, 146978-91, 147009-14, 148127-83, 149715-32, 149734-811, 149892-978, 149982, 150002-13, 150115, 152735-37; USNM 567396-410, 567423, 567425; YPM 13950-52; CP: ETMNH-CC 418-25, 427-32; UF 131544-47, 131556-60, 131764-66, 132864-83,

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- 133838-41, 135083-91, 135093-94, 144060, 144239, 150121; USNM 567424.
- Lampropeltis elapsoides*.—BBCF 144256-57.
- Leiocephalus personatus*.—CP 145733.
- Nerodia fasciata*.—CP: UF 131551.
- Osteopilus septentrionalis*.—BBCF: UF 134212-14, 134937, 134939, 134941, 135478, 135958, 137111, 140743-44, 140748-49, 140752-57, 143945, 144258; USNM 567210-12; CP: UF 131520.
- Pantherophis alleghaniensis*.—BBCF: UF 134211, 140944, 141228, 144251; CP: UF 131548.
- Pantherophis guttatus*.—VKB: UF 144249; BBCF: UF 134908-09, 137095, 144250; CP: UF 131548.
- Pseudocordylus microlepidotus*.—CP: UF 153698.
- Ramphotyphlops braminus*.—BBCF: UF 134932, 135956, 137672-73, 144252-55; CP: UF 144139-40.
- Rhinella marina*.—CP: UF 137719.
- Trachemys scripta elegans*.—CP: UF 146977, 147508-09.
- Tupinambis teguixin*.—CP: UF 149983.
- Uranoscodon superciliosus*.—CP 145734.