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Herpetofaunal Species Richness of Southeastern National Parks

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Abstract - The Southeast is the stronghold of US herpetofaunal biodiversity and comprises approximately half of the nation's species of amphibians and reptiles, of which about 20% are endemic. However, few areas have been inventoried, thus hampering efforts to monitor and protect populations. We conducted 2-year herpetological inventories of 16 parks within the National Park Service's Southeast Coast Network. We used a wide variety of standard field techniques to document species occurrences and augmented our collecting records with historical data from museums, published literature, and personal collections. We documented the presence of 123 native species of amphibians and reptiles at the 16 parks, with numbers of species ranging between 6 and 64 per park. Many southeastern parks support rich assemblages of herpetofauna.

Introduction

Inventories to develop site-specific lists of species typically precede monitoring efforts or research on populations and communities. Knowledge of species present at a specific site can direct conservation efforts and land management initiatives. The determination of species richness is the first step in evaluating local status and trends of species. In consideration of a nationwide effort to conserve native herpetofauna in natural habitats (Gibbons and Stangel 1999) and assist in a National Park Service (NPS) initiative to conduct biotic inventories, we recorded the presence of amphibian and reptile species on highly protected federal lands in the southeastern United States—16 parks that comprise the NPS's Southeast Coast Network. Compared to other taxonomic groups, occurrence of herpetofaunal species has been poorly documented on the majority of NPS lands, and minimal information is available on the status of populations (Stohlgren et al. 1995). Our purpose was to provide the most reliable species lists currently available for the herpetofauna of the 16 parks examined.

The Target Species: Southeastern Herpetofauna

The southeastern United States is the stronghold of amphibians and reptiles in the United States and Canada. Of the more than 450 US herpetofaunal species, approximately half occur in the Southeast and about 20% are endemic to the region (Conant and Collins 1998, Gibbons and

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Buhlmann 2001). Amphibians and reptiles are a significant component of the native biodiversity in virtually every natural terrestrial and freshwater habitat in the southeastern geographic region. Hence, the status of southeastern herpetofauna is likely to reveal the well-being of a habitat as well as the consequences of habitat destruction or other forms of environmental degradation (Knutson et al. 1999, Vitt et al. 1990).

Despite being often overlooked, amphibians and reptiles are vital components of southeastern ecosystems. They can serve important roles as both predators and prey (Gibbons and Dorcas 2004, Taylor et al. 1988), thus forming critical trophic links in many ecosystems. Additionally, the biomass of many populations can far exceed that of endotherms (Burton and Likens 1975, Godley 1980, Iverson 1982). Because of their biological characteristics and their functional roles in natural communities, the herpetofauna can collectively serve as indicators of environmental integrity (Gibbons et al. 2000); hence, comprehensive accounts of regional species composition and richness are fundamental to initiating meaningful monitoring or research programs applicable to conservation issues.

The Study Sites: Southeast Coast Network

Our study was conducted at 16 parks within the NPS's Southeast Coast Network (Fig. 1). The parks were located primarily in the Upper and Lower

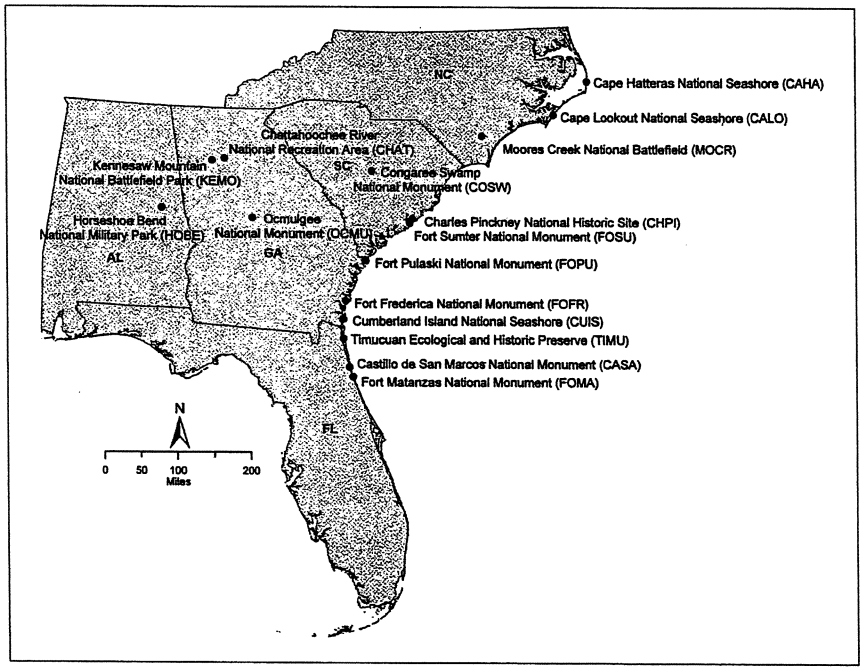

Figure 1. Park lands forming the National Park Service's Southeast Coast Network. Since the completion of this study, Congaree Swamp National Monument was designated Congaree National Park.

Coastal Plains of the southeastern US, from the Outer Banks of North Carolina, south to the Atlantic coast of northern Florida, and west into east-central Alabama. Parks ranged in size from 8.2 ha (Castillo de San Marcos National Monument) to 14,282 ha (Cape Hatteras National Seashore), and some consisted of disjunct parcels spanning as much as 112 km (Cape Hatteras National Seashore). Three "parks" were actually park groups—the Timucuan Ecological and Historical Preserve group also included Fort Caroline National Memorial; the Fort Sumter National Monument group included Fort Moultrie National Monument; and the Cape Hatteras National Seashore group included Wright Brothers National Memorial and Fort Raleigh National Historical Site.

The Southeast Coast Network includes parks protected for their historical or cultural resources—battlefields, forts, national monuments—as well as parks established to preserve environmental resources—ecological preserves and wilderness areas. As a result, the parks within the network exhibited a wide range of terrestrial and aquatic habitat diversity as well as relative proportions of native and anthropogenically altered habitats. In addition, the level of formal survey effort for amphibians and reptiles prior to our study varied dramatically among the parks—from no previous herpetofaunal inventory (e.g., Moores Creek National Battlefield, Fort Sumter National Monument) to extensive or intensive survey (e.g., Cape Hatteras National Seashore, Cumberland Island National Seashore, Fort Matanzas National Monument).

Methods

We conducted extensive field surveys and supplemented our findings with literature accounts, museum records, and personal collections and reports (Appendix 1). Field surveys were conducted from May 2001 through October 2003, although survey efforts varied from 11–259 person-days (not including assistance by park personnel) among parks, based on park size, habitat diversity within the park, and amount of prior survey work. Our survey efforts typically were more intense at larger parks having a greater diversity of habitats and at parks where little or no previous inventory had been conducted (i.e., presumably with high numbers of previously undocumented species). Additionally, field surveys were concentrated during times when conditions favored amphibian and reptile activity or when targeted species were known to be active (e.g., during spring rainy periods).

Evaluating the status of herpetofauna can be difficult because most species are clandestine and many have low activity levels, low abundance, or both. Therefore, determining species richness requires numerous techniques, careful planning, experienced personnel, and a considerable investment of time (Gibbons et al. 1997, Heyer et al. 1994). We used a wide variety of standard herpetological sampling techniques at each park including coverboards, terrestrial drift fences, aquatic dip netting, aquatic traps, automated recording of calling anurans, road-cruising, and opportunistic

visual searches (Fitch 1987, Heyer et al. 1994, Vogt 1980). In addition to captures of live animals, we collected and identified turtle shells, shed snake skins, reptile egg shells, and road kills. Park personnel provided assistance in some instances.

When possible, photographs, specimen vouchers, or both were obtained for each species found at each park (i.e., each species-park occurrence). Specimen and photo vouchers from Timucuan Ecological and Historic Preserve are housed in the museum at the site, as required by NPS. Specimens and photo vouchers for the remaining 15 parks are deposited in the Auburn University Museum and Charleston Museum.

Results

We recorded 123 of the 147 native species of amphibians (Appendix 2) and reptiles (Appendix 3) within range of or peripheral to the NPS's Southeast Coast Network, plus 8 introduced species. The total number of species (native plus introduced) documented from parks ranged from 6–64 per park, resulting in a total of 642 species-park occurrences (Appendix 4). Species richness was strongly and positively correlated with park size (Fig. 2; linear regression of log-transformed data, $R^2 = 0.5434$, $P = 0.001$). We documented at least 26 new county records during the study. Our surveys documented 7 federally listed reptile species and 14 reptile and 1 amphibian species having state status of special concern (e.g., State Threatened or Endangered) in one or more of the states where they were found. We found at least one introduced amphibian or reptile species in six parks (Appendices 2–4).

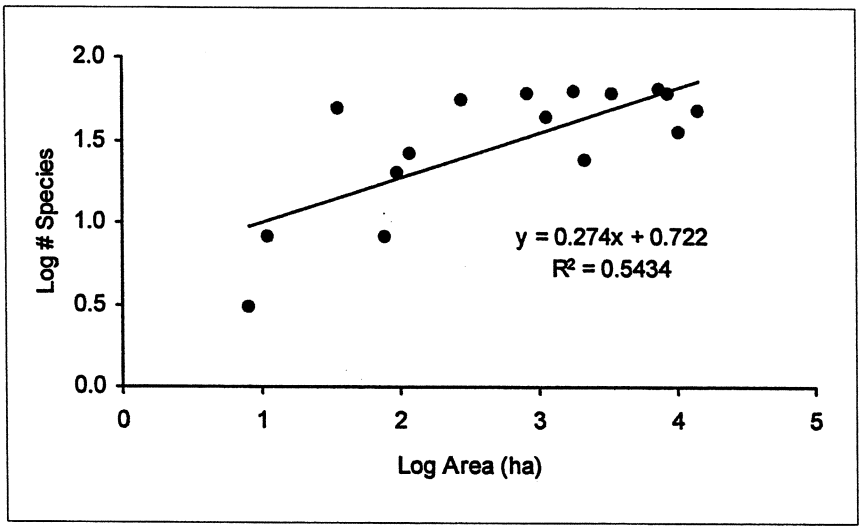

Figure 2. Relationship between land area (ha) and species richness among the 16 parks we surveyed within the Southeast Coast Network. Note the strong positive linear relationship between (log-transformed) land area and species richness ($P = 0.001$). Introduced species are not included in species richness values.

In general, reptiles constituted a much greater proportion of the overall herpetofaunal species richness than did amphibians. Among the reptiles, snakes contributed the greatest number of within-range species (Appendix 3) and the greatest proportion of documented species (Appendix 4). Although anurans typically represented 20–30% of total species documented within a park, salamander richness was consistently low, particularly for coastal and island parks (Appendices 1 and 4; Fig. 1).

Several parks had been the focus of previous formal herpetofaunal surveys, contributing to the high number of species documented through museum collections, records published in the literature or available as reports, or both (Appendices 1 and 4). In addition, several herpetologists provided personal observations of amphibians and reptiles for specific parks that previously were unreported (e.g., Horseshoe Bend National Military Park, Kennesaw Mountain National Battlefield Park, Ocmulgee National Monument; Appendices 2 and 4).

Discussion

For most of the 16 parks, our surveys increased the number of documented herpetofaunal species considerably, and thus provide the most complete list of species present or historically present. Despite variable field sampling efforts among parks, due in part to differences in habitat complexity and extent of historical information available, the species lists are the most accurate yet available for each of the parks. The lists should represent a high proportion of the herpetofaunal species actually present and allow relative comparison of species richness among the 16 parks.

In general, parks with high herpetofaunal richness tended to be large in size and have a high diversity of habitats (e.g., Chattahoochee River National Recreation Area, Congaree Swamp National Monument, Timucuan Ecological and Historical Preserve). Parks with a low herpetofaunal richness (e.g., Fort Sumter National Monument, Castillo de San Marcos National Monument, Charles Pinckney National Historic Site) typically were small in size, lacked freshwater habitats, and contained a high proportion of anthropogenically modified habitats. In some small parks containing a high diversity of habitat types, we found an unusually rich assemblage of amphibians and reptiles. These included Moores Creek National Battlefield, Horseshoe Bend National Military Park, and Ocmulgee National Monument, all three of which were established solely for their historical resources. Both Ocmulgee National Monument and Horseshoe Bend National Military Park are located near the Fall Line along the boundary between the Piedmont and Coastal Plain, and their resident herpetofauna included species characteristic of both physiographic provinces.

We documented eight species of amphibians and reptiles that presumably had been introduced, mostly in parks in Florida or southern Georgia. The two introduced species of turtles documented during our field surveys, the Pond Slider (*Trachemys scripta*) at Timucuan Ecological and Historical

Preserve and the Florida Red-bellied Cooter (*Pseudemys nelsoni*) at Chattahoochee River National Recreation Area, are native to the Southeast, but are not within-range of the parks from which they were documented. We strongly suspect that the single *P. nelsoni* captured at Chattahoochee was a released captive because of plastron abrasions characteristic of captive animals (P. Pritchard, Chelonian Research Institute, Oviedo, FL, pers. comm.). None of the remaining introduced species (4 lizards and 2 anurans) are native to the United States.

Twenty-four species within or peripheral to the geographic range of at least one of the parks were not documented in any park during our study (Appendices 2–3). Several explanations can be given for why these species were not documented during our surveys or in previous efforts. Many or most of the undocumented species listed as "within-range" probably do not actually occur at the park in question. Because we were liberal when including species as "within range," ranges of some species (e.g., *A. mutica, A. texanum, D. ocoee, G. nigrinoda, N. clarkii, N. rhombifer*) were adjacent to or had minimal overlap with the Southeast Coast Network. Thus, if a species is present at all, it may only occur in low numbers or only at isolated locations in a region. In addition, the clandestine nature of many species (e.g., *R. floridana, H. simus*) makes them particularly difficult to sample even in locations where they are known to occur. Therefore, it is not surprising that some of the species potentially occurring within the Southeast Coast Network were never documented at any of the parks, either because they are not actually present or are characteristically difficult to detect.

Several herpetologically important habitats were underrepresented in Southeast Coast Network parks, resulting in the absence of some species that would otherwise be expected to be present based on broad scale geographic range maps. Longleaf pine forests support many species of amphibians and reptiles (Guyer and Bailey 1993) and are habitats of major conservation concern in the southeastern United States. Longleaf pine ecosystems have been severely impacted by humans (Frost 1993), and such habitats within the Southeast Coast Network parks are limited. Other habitats critical for southeastern herpetofauna, but that are poorly represented at parks within the network, are isolated wetlands (Kirkman et al. 1999, Semlitsch and Bodie 1998). Consequently, amphibians and reptiles (including several federally protected species) typically associated with these habitats were underrepresented or undocumented during our study. Amphibians included the Gopher Frog (*R. capito*), Flatwoods Salamander (*A. cingulatum*), Tiger Salamander (*A. tigrinum*), and Striped Newt (*N. perstriatus*). Reptiles included the Mole Skink (*E. egregius*), Pine Snake (*P. melanoleucus*), Southern Hognose Snake (*H. simus*), and Eastern Indigo Snake (*D. corais*). Future land acquisition and management decisions by the NPS should consider inclusion of these and other underrepresented habitats to conserve the full spectrum of southeastern herpetofauna.

Inventory is a critical first step in monitoring and managing biodiversity (Andrewartha and Birch 1954, Krebs 1972). Biodiversity patterns in protected areas can be compared to the surrounding landscape to determine the effects of specific land-use patterns on biodiversity. For example, a study conducted in the Piedmont of North Carolina concluded that although some sensitive or rare species may become extirpated in undeveloped areas surrounded by extensive regional urbanization, the protected areas can continue to support relatively high numbers of amphibian and reptile species (Rice et al. 2001). Baseline inventories, when combined with subsequent monitoring, also can be used to detect and evaluate temporal trends in species richness and abundance. Unfortunately, the terms "inventory" and "monitoring" frequently are misused or are used interchangeably, even though the goals (and therefore the techniques and procedures) of one are quite different from the other. The primary goal of inventory is to document the presence of target species in a given area; the purpose of monitoring is to evaluate the status and population trends of those species that are known to be present. Although our multi-pronged survey approach proved to be an effective and efficient tactic for conducting inventories at a large number of sites during a relatively short time period, future monitoring will be required to determine population viability and status of species documented within the parks. In addition, active management of some habitats will be necessary to ensure the long-term persistence of certain amphibian and reptile species within these protected areas.

Government-managed lands "encompass 29% of the land area in the United States" (Gibbons et al. 1997), mostly in the West, with over 32 million ha set aside within the National Park System alone (Stohlgren et al. 1995). The National Park System is a major contributor to the protection of land and biodiversity, and national parks often serve as habitat havens for numerous species of indigenous amphibians and reptiles. These parks become especially important in situations in the Southeast where encroaching urban development (e.g., Ocmulgee National Monument, Chattahoochee River National Recreation Area) or agricultural impacts (e.g., Congaree Swamp National Monument, Horseshoe Bend National Military Park) may have resulted in local extirpations in a region. Thus, the potential contribution of protected lands in the National Park System to biodiversity conservation is far-reaching and should be widely recognized and appreciated by land managers, conservation biologists, and the general public.

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Appendix 1. List of data sources (by park) documenting reptile and amphibian species occurrences reported in Appendix 2–3.

Cape Hatteras National Seashore (CAHA)—*Literature records:* Beane 1998, Braswell 1988, Braswell 1997, Engels 1942, Gaddy et al. 1999, Gibbons and Coker 1978, Lazell and Musick 1973, Quay 1959, Stoneburner and Ehrhart 1981, Woodson and Webster 1999; *Museum records:* American Museum of Natural History, Carnegie Museum, Cornell University Museum, Harvard - Museum of Comparative Zoology, North Carolina State Museum; *Pers. comm.:* A. Braswell, R. Gaul and J. Mitchell, S. O'Neil, N.I. Turner (pers. notes, NPS files).

Cape Lookout National Seashore (CALO)—*Literature records:* Blaney 1979, Engels 1952, Gibbons and Coker 1978, Lazell and Musick 1973, National Park Service 1977; *Museum records:* American Museum of Natural History, Harvard - Museum of Comparative Zoology, North Carolina State Museum. *Pers. comm.:* NPS personnel.

Castillo de San Marcos (CASA)—none

Chattahoochee River National Recreation Area (CHAT)—*Museum records:* University of Georgia Museum of Natural History; *Pers. comm.:* J. Hightower, L. Wilson.

Charles Pinckney National Historic Site (CHPI)—none

Congaree Swamp National Monument (COSW)—*Literature records:* Cely and Bennett 1985, Mancke 1979; *Pers. comm.:* Cely (1996, to NPS), R. Mancke, Nathan Taylor, and NPS personnel.

Cumberland Island National Seashore (CUIS)—*Literature records:* Gibbons and Coker 1978, Hillestad et al. 1975, Lenarz et al. 1981, Ruckdeschel et al. 1982, Shoop and Ruckdeschel 1986, Shoop and Ruckdeschel 1997, Shoop and Ruckdeschel 2000; *Museum records:* Carnegie Museum, Cumberland Island Museum, National Park Service – Cumberland Island Natural History Collection, University of Georgia Museum of Natural History, Williamson and Moulis 1994a, Williamson and Moulis 1994b.

Fort Frederica National Monument (FOFR)—*Museum records:* Williamson and Moulis 1994a, Williamson and Moulis 1994b, University of Georgia Museum of Natural History.

Fort Matanzas National Monument (FOMA)—*Literature records:* King and Krysko 1999, Krysko and King 1999, Krysko and King 2000, McCoy and Mushinsky 1992; *Museum records:* Florida Museum of Natural History.

Fort Pulaski National Monument (FOPU)—*Literature records*: Rabolli and Ellington 1999, Southeastern Wildlife Services 1981; *Museum records*: Cornell University, Williamson and Moulis 1994a, Williamson and Moulis 1994b; *Pers. comm.:* NPS files.

Fort Sumter/Fort Moultrie (FOSU)—none

Horseshoe Bend National Military Park (HOBE)—*Literature records:* Hanlin and Russell 1978; *Museum records:* Auburn University Museum; *Pers. comm.:* H. Hanlin.

Kennesaw Mountain National Battlefield Park (KEMO)—*Museum records:* University of Georgia Museum of Natural History, Williamson and Moulis 1994a; *Pers. comm.*: G. Beaton, L. Wilson.

Moores Creek National Battlefield (MOCR)—*Museum records:* North Carolina State Museum; *Pers. comm.*: NPS personnel.

Ocmulgee National Monument (OCMU)—*Literature records:* Jensen and Moulis 1997; *Pers. comm.:* H. Berna, NPS personnel.

Timucuan Ecological and Historical Preserve (TIMU)—*Museum records:* American Museum of Natural History, Florida Museum of Natural History; *Pers. comm.:* B. Mansel, P. Moler.

Appendix 2. Amphibian species documented during herpetofaunal surveys of the National Park Service's Southeast Coast Network: (o) park not within geographic range, (S) documented by SREL field surveys, (M) documented by a previously existing museum specimen, (L) documented by a published literature record, (P) documented by a reliable personal communication. Introduced species were not considered potential species unless they were documented. Data sources for this table are listed by park in Appendix 1. Full names for parks are provided in Figure 1 and Appendix 1. TIMU includes Ft. Caroline National Monument; FOSU includes Fort Moultrie National Monument; CAHA includes Wright Brothers National Memorial and Fort Raleigh National Historic Site. Scientific names follow Crother (2000).

	TIMU	CAHA	CALO	CASA	CHAT	CHPI	COSW	CUIS	FOFR	FOMA	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU
Anurans																
Acris crepitans Baird, 1854 Northern Cricket Frog	o	o	o	o	P	o	S	o	o	o		o	S,P	S,P	o	S
Acris gryllus (Le Conte, 1825) Southern Cricket Frog	S,M						L	L			P		S		S	S,P
Bufo americanus Holbrook, 1836 American Toad	o	o	o	o	S,P	o	o	o	o	o	o	o	S	P	o	S
Bufo terrestris (Bonnaterre, 1789) Southern Toad	S,M	L[2]		S	o	S	S,L	S,M,L	S	M,L	S,M,L	S		o	S	S,M,P,L
Bufo fowleri Hinckley, 1882 Fowler's Toad	o	S,M,L	M,L	o	S,M,P	o		o	o	o	o	o	S,P	S,P	S	S
Bufo quercicus Holbrook, 1840 Oak Toad			M[4]		o			L[6]						o		
Gastrophryne carolinensis (Holbrook, 1836) Eastern Narrowmouthed Toad	S,M	S,M,L	S,M,L		M,P		S	S,M,L	S	M,L	S,M,L	S	S,P		S	S,P

	TIMU	CAHA	CALO	CASA	CHAT	CHPI	COSW	CUIS	FOFR	FOMA	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU
Hyla andersonii (Holbrook, 1836) Pine Barrens Treefrog	o	o	o	o	o	o		o	o	o	o	o	o	o		o
Hyla avivoca Viosca, 1928 Birdvoiced Treefrog	o	o	o	o		o	o	o	o	o		o	S		o	S
Hyla chrysoscelis Cope, 1880 /*versicolor* Le Conte, 1825 Gray Treefrog		L			S,P		S,L	L[6]					S,P	P	S	S
Hyla cinerea Schneider, 1799 Green Treefrog	S,M	S,M,L	S,M,L				S,L	M,L		M,L	S,L	S	S,L,P		S	S,M,P,L
Hyla femoralis Bosc in Daudin, 1800 Pine Woods Treefrog	S	L[3]			o		S	M,L						o	S	
Hyla gratiosa Le Conte, 1856 Barking Treefrog	P				o		S,L	L	S				S	o	S	
Hyla squirella Bosc in Daudin, 1800 Squirrel Treefrog	S	S,M,L	S,M,L	S	o		S	M,L	S	S,M,L	S,L			o	S	S
Pseudacris brachyphona (Cope, 1889) Mountain Chorus Frog	o	o	o	o	o	o	o	o	o	o	o	o	S	o	o	o
Pseudacris brimleyi Brandt and Walker, 1933 Brimley's Chorus Frog	o			o	o		S	o	o	o			o	o		o

	TIMU	CAHA	CALO	CASA	CHAT	CHPI	COSW	CUIS	FOFR	FOMA	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU
Pseudacris crucifer (Wied Neuwied, 1839) Spring Peeper	S				P		S,L	S,M,L					S,P	P	S	S
Pseudacris feriarum (Baird, 1854) Southeastern Chorus Frog	o	o	o	o	S,M,P		S			o			S	S,P	S	
Pseudacris nigrita (Le Conte, 1825) Southern Chorus Frog					o		S	L[6]						o		S
Pseudacris ocularis (Bosc and Daudin in Sonnini and Latreille, 1801) Little Grass Frog	S,M	M,L[3]	M[4]		o			S,L			L			o	S	
Pseudacris ornata (Holbrook, 1836) Ornate Chorus Frog					o		S,L							o	S	S
Rana capito Le Conte, 1855 Gopher Frog	M				o									o		
Rana catesbeiana Shaw, 1802 American Bullfrog	S	S,M,L			S,P		S,L						S,P	S,P	S	S
Rana clamitans Latreille in Sonnini and Latreille, 1801 Green Frog	S	L[2]			S,M,P		S,L						S,P	S,M,P	S	S,P
Rana palustris Le Conte, 1825 Pickerel Frog	o			o	S,P		S	o	o	o			S,M	P	S	o

	TIMU	CAHA	CALO	CASA	CHAT	CHPI	COSW	CUIS	FOFR	FOMA	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU
Rana sylvatica Le Conte, 1825 Wood Frog	o	o	o	o	o	o	o	o	o	o	o	o	S	o	o	o
Rana grylio Stejneger, 1901 Pig Frog	S	o	o		o		o	M,L					o	o	o	o
Rana heckscheri Wright, 1924 River Frog		o	o		o		P						o	o		o
Rana sphenocephala Cope, 1889 Southern Leopard Frog	S	S,M,L	M,L		S,P	S	S,L	S,M,L		M,L	L		S,P	S,P	S	S,P
Rana virgatipes Cope, 1891 Carpenter Frog	o				o		S,L			o			o	o		o
Scaphiopus holbrookii (Harlan, 1835) Eastern Spadefoot	M		S,M,L		M,P		S	M,L	S	M,L		S	P		S	
Salamanders																
Ambystoma cingulatum (Cope, 1868) Flatwoods Salamander		o	o		o		o						o	o	o	o
Ambystoma opacum Gravenhorst, 1807) Marbled Salamander	o			o	S,M,P		S,L			o			S	P	S	S
Ambystoma mabeei Bishop, 1928 Mabee's Salamander	o		M[4]	o	o			o	o	o			o	o		o

	TIMU	CAHA	CALO	CASA	CHAT	CHPI	COSW	CUIS	FOFR	FOMA	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU
Ambystoma maculatum (Shaw, 1802) Spotted Salamander	o			o	S,M,P			o	o	o			S	P	o	
Ambystoma talpoideum (Holbrook, 1838) Mole Salamander	S,P	o	o				P	L					S		o	
Ambystoma texanum (Matthes, 1855) Smallmouthed Salamander	o	o	o	o	o	o	o	o	o	o	o	o		o	o	o
Ambystoma tigrinum (Green, 1825) Tiger Salamander																
Amphiuma means Garden in Smith, 1821 Twotoed Amphiuma		S,M,L			o			M,L						o	S	S
Desmognathus aeneus Brown and Bishop, 1947 Seepage Salamander	o	o	o	o		o	o	o	o	o	o	o			o	o
Desmognathus fuscus/conanti (Green, 1818) Dusky Salamander	o	o	o	o	P	o		o	o	o	o	o	S	S,M,P	o	S
Desmognathus monticola Dunn, 1916 Seal Salamander	o	o	o	o	S,P	o	o	o	o	o	o	o		S	o	o
Desmognathus ocoee Nicholls, 1949 Ocoee Salamander	o	o	o	o		o	o	o	o	o	o	o	o		o	o

	TIMU	CAHA	CALO	CASA	CHAT	CHPI	COSW	CUIS	FOFR	FOMA	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU
Desmognathus auriculatus (Holbrook, 1838) Southern Dusky Salamander					o		S,L	M,L					o	o	S	S
Eurycea cirrigera (Holbrook, 1838) Southern Twolined Salamander	o			o	S,M,P					o	L		S,P	S,M,P		S
Eurycea guttolineata (Holbrook, 1838) Threelined Salamander	o	o	o	o	S,P		S,L	o	o	o			S,P	S		S
Eurycea quadridigitata (Holbrook, 1842) Dwarf Salamander	S				o			L						o		
Gyrinophilus porphyriticus (Green, 1827) Spring Salamander	o	o	o	o	S,M,P	o	o	o	o	o	o	o	S	S	o	o
Hemidactylium scutatum (Temminck and Schlegel in Von Siebold, 1838) Fourtoed Salamander	o	o	o	o		o		o	o	o	o	o				o
Necturus punctatus (Gibbes, 1850) Dwarf Waterdog	o	o	o	o	o		S			o			o	o		
Necturus alabamensis Viosca, 1937 Blackwarrior Waterdog	o	o	o	o	o		o	o	o	o	o	o			o	o
Notophthalmus perstriatus (Bishop, 1941) Striped Newt	P[1]	o	o		o	o	o					o	o	o	o	o

	TIMU	CAHA	CALO	CASA	CHAT	CHPI	COSW	CUIS	FOFR	FOMA	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU
Notophthalmus viridescens (Rafinesque, 1820) Eastern Newt	S,P		M[4]		S,P			L					S,M,P			
Plethodon glutinosus complex (Green, 1818) Slimy Salamander	M	M,L[3]			S,P	S	S,L						S,P	S,M,P	S	S,P
Plethodon cinereus (Green, 1818) Eastern Redbacked Salamander	o	S,L[2]	o	o	o	o	o	o	o	o	o	o	o	o	o	o
Plethodon serratus Grobman, 1944 Southern Redbacked Salamander	o	o		o	S,P	o	o	o	o	o	o	o	o	S,M,P	o	o
Plethodon websteri Highton, 1979 Webster's Salamander	o	o	o	o			o	o	o	o	o	o		S,M,P	o	o
Pseudobranchus striatus (Le Conte, 1824 Northern Dwarf Siren		o	o		o		o						o	o	o	o
Pseudotriton montanus Baird, 1849 Mud Salamander							S,L						P			
Pseudotriton ruber (Latreille in Sonnini and Latreille, 1801) Red Salamander	o	o	o	o	S,M,P	o		o	o	o	o	o	S,P	S,P	o	S

	TIMU	CAHA	CALO	CASA	CHAT	CHPI	COSW	CUIS	FOFR	FOMA	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU
Siren intermedia Barnes, 1826 Lesser Siren					o									o	M	
Siren lacertina Linnaeus, 1766 Greater Siren					o		S,L						o	o	S	
Stereochilus marginatus (Hallowell, 1856) Manylined Salamander	o			o	o		o			o			o	o		o
Introduced amphibians																
Eleutherodactylus planirostris (Cope, 1862) Greenhouse Frog	S			S					S	M,L						
Osteopilus septentrionalis Duméril and Bibron, 1841 Cuban Treefrog				S						M,L						

[1]Reported historically, not found in contemporary surveys.
[2]Reported only from Wright Brothers National Memorial, Kill Devil Hills, Bodie Island; apparently not established within park boundaries at other sites.
[3]Reported only from Ft. Raleigh National Historic site on Roanoke Island; apparently not established within park boundaries on Hatteras, Bodie, or Ocracoke Islands.
[4]Reported only from NPS land on Harker's Island; apparently not established on Shackleford or Core Banks.
[5]Reported by Hillestad et al. (1975); not found in contemporary surveys and believed to be erroneous by Shoop and Ruckdeschel (2000).

Appendix 3. Reptiles documented during herpetofaunal surveys of the National Park Service's Southeast Coast Network: (o) park not within geographic range, (S) documented by SREL field surveys, (M) documented by a previously existing museum specimen, (L) documented by a published literature record, (P) documented by a reliable personal communication. Introduced species and marine turtles were not considered potential species unless they were documented. Data sources for this table are listed by park in Appendix 1. Full names for parks are provided in Figure 1 and Appendix 1. TIMU includes Ft. Caroline National Monument; FOSU includes Fort Moultrie National Monument; CAHA includes Wright Brothers National Memorial and Fort Raleigh National Historic Site. Scientific names follow Crother (2000).

	TIMU	CAHA	CALO	CASA	CHAT	CHPI	COSW	CUIS	FOFR	FOMA	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU
Crocodilians																
Alligator mississippiensis (Daudin, 1803) American Alligator	S	M,L[6]			o		S	L	P[6]		S,L			o		S
Turtles																
Apalone mutica LeSueur, 1827 Smooth Softshell	o	o	o	o	o	o	o	o	o	o	o	o		o	o	o
Apalone ferox Schneider, 1783 Florida Softshell	S	o	o		o		o	L					o	o	o	o
Apalone spinifera LeSueur, 1827 Spiny Softshell		o	o	o	P					o			S,P			
Chelydra serpentina (Linnaeus, 1758) Snapping Turtle	S	S,M	S,L		S,P		S,L	M,L					S,P	P		S,P
Chrysemys picta (Schneider, 1783) Painted Turtle	o			o	S,M,P	o		o	o	o	o	o		S	o	S

	TIMU	CAHA	CALO	CASA	CHAT	CHPI	COSW	CUIS	FOFR	FOMA	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU
Clemmys guttata (Schneider, 1801) Spotted Turtle		M,L	M,L		o		P						o	o		
Deirochelys reticularia (Latreille in Sonnini and Latrielle, 1801) Chicken Turtle					o			M,L	S					o		o
Graptemys nigrinoda Cagle, 1954 Blackknobbed Map Turtle	o	o	o	o	o	o	o	o	o	o	o	o		o	o	o
Graptemys pulchra Baur, 1893 Alabama Map Turtle	o	o	o	o	o	o	o	o	o	o	o	o		o	o	o
Gopherus polyphemus (Daudin, 1802) Gopher Tortoise	S,P	o	o		o	o	o	L[7]		S,M,L		o	o	o	o	
Kinosternon baurii (Garman, 1891) Striped Mud Turtle	M				o			L					o	o	S	
Kinosternon subrubrum (Lacépède, 1788) Eastern Mud Turtle		S,M,L	M,L		P		S,L	S,L					S,P		S	S,P
Macroclemys temminckii (Troost in Harlan, 1835) Alligator Snapping Turtle	o	o	o	o	o	o	o	o	o	o	o	o		o	o	o
Malaclemys terrapin (Schoepff, 1793) Diamondbacked Terrapin	M,P	M,L	M,L		o		o	M,L	S	S	S,L		o	o	o	o

	TIMU	CAHA	CALO	CASA	CHAT	CHPI	COSW	CUIS	FOFR	FOMA	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU
Pseudemys peninsularis (Carr, 1938) Peninsula Cooter	S	o	o		o	o	o	o	o		o	o	o	o	o	o
Pseudemys concinna (Le Conte, 1830) River Cooter	o			o	S,P		S			o			S,M,P		S	S,P
Pseudemys rubriventris (Le Conte, 1830) Northern Redbellied Cooter	o	M,L[3]		o	o	o	o	o	o	o	o	o	o	o	o	o
Pseudemys nelsoni Carr, 1938 Florida Redbellied Cooter	S	o	o		o	o	o	M,L			o	o	o	o	o	o
Sternotherus minor (Agassiz, 1857) Loggerhead Musk Turtle	M	o	o		P	o	o					o	S		o	
Sternotherus odoratus (Latreille in Sonnini and Latrielle, 1801) Stinkpot	S				S,M,P		S,L						S	S,P	S	S,P
Terrapene carolina (Linnaeus, 1758) Eastern Box Turtle	M	L[2]	S[4]		S,P		S,L			M,L	S		S,P	S,P	S	S,P
Trachemys scripta (Schoepf, 1792) Pond Slider	o	S,M,L		o	S,P		S,L	M,L		o	S,L		S,P	S	S	S,P
Marine Turtles																
Caretta caretta (Linnaeus, 1758) Loggerhead Seaturtle		M,L	S,M,L		o	o	o	M,L		L			o	o	o	o

	TIMU	CAHA	CALO	CASA	CHAT	CHPI	COSW	CUIS	FOFR	FOMA	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU
Chelonia mydas (Linnaeus, 1758) Green Seaturtle		M,L	M		o	o	o	M,L		L			o	o	o	o
Dermochelys coriacea (Linnaeus, 1766) Leatherback Seaturtle		L	M,L		o	o	o	M,L		L,S			o	o	o	o
Eretmochelys imbricata (Linnaeus, 1766) Hawksbill Seaturtle					o	o	o	M,L					o	o	o	o
Lepidochelys kempii (Garman, 1880) Kemp's Ridley Seaturtle		L	P		o	o	o	M,L					o	o	o	o
Lizards																
Anolis carolinensis Voigt, 1832 Green Anole	S,M	S,M,L	S,M,L		S,M,P	S	S,L	S,M,L	S	S,M,L	S,L	S	S,P	S,P	S	S,P
Cnemidophorus sexlineatus (Linnaeus, 1766) Sixlined Racerunner	S,M	S,M,L	S,M,L		M,P			M,L	S	S,M,L		S	M,P		S	S
Eumeces egregious (Baird, 1859) Mole Skink		o	o		o	o	o	M,L				o	P	o	o	
Eumeces anthracinus (Baird, 1850) Coal Skink	o	o	o	o		o	o	o	o	o	o	o			o	o
Eumeces fasciatus (Linnaeus, 1758) Common Fivelined Skink					S,M,P	S	S,L	L[5]					S,P	S,P	S	S,P

	TIMU	CAHA	CALO	CASA	CHAT	CHPI	COSW	CUIS	FOFR	FOMA	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU
Eumeces inexpectatus Taylor, 1932 Southeastern Fivelined Skink	S	S,M,L	S,M,L		P		S,L	M,L		S,M,L	L		P		S	P
Eumeces laticeps (Schneider, 1801) Broadheaded Skink	S	M,L[3]			S,P	S	S,L	M,L	S				S,P		S	S,P
Ophisaurus attenuatus Cope, 1880 Slender Glass Lizard	P[1]				P											
Ophisaurus compressus Cope, 1900 Island Glass Lizard		o	o		o		o	M,L					o	o	o	o
Ophisaurus mimicus Palmer, 1987 Mimic Glass Lizard					o		o						o	o		o
Ophisaurus ventralis (Linnaeus, 1766) Eastern Glass Lizard	S,M	S,M,L	S,M,L		P			M,L	S	M,L	S,M,L					
Rhineura floridana (Baird, 1859) Florida Worm Lizard		o	o		o	o	o	o	o		o	o	o	o	o	o
Sceloporus undulatus (Latreille in Sonnini and Latrielle, 1802) Eastern Fence Lizard	S				S,P			S,M,L					S	S,M,P	S	S,P
Scincella lateralis (Say in James, 1823) Little Brown Skink	S	S,M,L	S,M,L		S,P	S	S,L	S,M,L	S,M	M,L	L		S,P	S,P	S	S,P

	TIMU	CAHA	CALO	CASA	CHAT	CHPI	COSW	CUIS	FOFR	FOMA	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU
Snakes																
Agkistrodon contortrix (Linnaeus, 1766) Copperhead	o			o	S,P		S,L			o			S,P	P	S	P
Agkistrodon piscivorus (Linnaeus, 1766) Cottonmouth	P[1]	S,M,L	L[8]				S,L	M,L			L[1]		S		S	S
Carphophis amoenus (Say, 1825) Eastern Wormsnake	o			o	S,P		L	o	o	o			M,L	M,L,P	S	S
Cemophora coccinea (Blumenbach, 1788) Scarletsnake	S,M				P			M,L	S							
Coluber constrictor Linnaeus, 1758 Eastern Racer	S	S,M,L	S,M,L		S,M,P		S,L	S,M,L	S	S,M,L	S,M,L	S	P	S,P	S	S,P
Crotalus adamanteus Palisot de Beauvois, 1799 Eastern Diamondbacked Rattlesnake	S,M	L[9]			o		o	M,L		S,M,L	S,M,L		o	o		o
Crotalus horridus Linnaeus, 1758 Timber Rattlesnake		M,L		o			S,L	L		o			P			P
Diadophis punctatus (Linnaeus, 1766) Ringnecked Snake	S	M,L			S,M,P		S,L	M,L					S,P	S,P		S
Drymarchon corais (Boie, 1827) Eastern Indigo Snake	P[1]	o	o		o	o	o			M,L		o	o	o	o	o

	TIMU	CAHA	CALO	CASA	CHAT	CHPI	COSW	CUIS	FOFR	FOMA	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU
Elaphe guttata (Linnaeus, 1766) Cornsnake	M	S,M			P			M,L	M	M,L	M,L			P		P
Elaphe obsoleta (Say in James, 1823) Eastern Ratsnake	S	M,L	M,L		S,P	S	S,L	M,L	S	M,L	M,L	S	P	S,P	S	S,M
Farancia abacura (Holbrook, 1836) Redbellied Mudsnake					o		L	M,L						o		
Farancia erytrogramma (Palisot De Beauvois in Sonnini and Latreille, 1801) Rainbow Snake		M,L[3]			o								o	o	S	
Heterodon platirhinos Latreille in Sonnini and Latrielle, 1801 Eastern Hognosed Snake		M,L	M,L		S,P		L									
Heterodon simus (Linnaeus, 1766) Southern Hognosed Snake					o									o		
Lampropeltis calligaster (Harlan, 1827) Yellowbellied Kingsnake	o			o	P			o	o	o						
Lampropeltis getula (Linnaeus, 1766) Common Kingsnake	P[1]	M,L	M,L		S,P		S,L	M,L	S		L		S,P	S,P	S,M	S,P

	TIMU	CAHA	CALO	CASA	CHAT	CHPI	COSW	CUIS	FOFR	FOMA	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU
Lampropeltis triangulum (Lacépède, 1788) Milksnake	M,P				P			M,L								
Masticophis flagellum (Shaw, 1802) Coachwhip							P	S,M,L		M,L			M			
Micrurus fulvius (Linnaeus, 1766) Harlequin Coralsnake		o			o								o	o		o
Nerodia erythrogaster (Forster, 1771) Plainbellied Watersnake	o			o	M,P		S,L			o			S,P	P	S	S,P
Nerodia clarkii (Baird and Girard, 1853) Saltmarsh Snake	o	o	o	o	o	o	o	o	o		o	o	o	o	o	o
Nerodia fasciata (Linnaeus, 1766) Southern Watersnake	S,M	M,L[3]	M,L		o		S,L	L			S		o	o	S	S,P
Nerodia rhombifer (Hallowell, 1852) Diamondbacked Watersnake	o	o	o	o	o	o	o	o	o	o	o	o		o	o	o
Nerodia sipedon (Linnaeus, 1758) Northern Watersnake	o	M,L	M,L	o	S,M,P	o		o	o	o	o	o	S,P	S	o	
Nerodia floridana (Goff, 1936) Florida Green Watersnake		o	o		o		o	o	o		o		o	o	o	o

	TIMU	CAHA	CALO	CASA	CHAT	CHPI	COSW	CUIS	FOFR	FOMA	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU
Nerodia taxispilota (Holbrook, 1838) Brown Watersnake		L		o			S,L								S	S,P
Opheodrys aestivus (Linnaeus, 1766) Rough Greensnake	S	M,L	M,L		S,M,P		S,L	M,L		S,M,L	S,L		S,P	P	P	S,P
Pituophis melanoleucus (Daudin, 1803) Pinesnake	P[1]	o						L[5]								
Regina alleni (Garman, 1874) Striped Crayfish Snake		o	o		o	o	o	o	o		o	o	o	o	o	o
Regina rigida (Say, 1825) Glossy Crayfish Snake				o	o								o	o		o
Regina septemvittata (Say, 1825) Queen Snake	o	o	o	o	S,P	o		o	o	o	o	o	M,P		o	o
Rhadinaea flavilata (Cope, 1871) Pine Woods Littersnake	S		M,L	S	o			L[10]		M,L			o	o		o
Seminatrix pygaea (Cope, 1871) Black Swampsnake	S				o								o	o		o
Sistrurus miliarius (Linnaeus, 1766) Pigmy Rattlesnake	P[1]		L[8]													

	TIMU	CAHA	CALO	CASA	CHAT	CHPI	COSW	CUIS	FOFR	FOMA	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU
Storeria dekayi victa (Holbrook, 1839) DeKay's/Florida Brownsnake	P[1]	S,M,L			S,P		S						S,P	P		P
Storeria occipitomaculata (Storer, 1839) Redbellied Snake	S				S,P		S,L	M,L	S				S	P		
Tantilla coronata Baird and Girard, 1853 Southeastern Crowned Snake	o				P			o	o	o						
Thamnophis sauritus (Linnaeus, 1766) Eastern Ribbonsnake	M,P	S,M,L	M,L		P		L	M,L		L						S,P
Thamnophis sirtalis (Linnaeus, 1758) Common Gartersnake	S,P				S,P		S	M,L	S				P	P		
Virginia striatula (Linnaeus, 1766) Rough Earthsnake	S				o									o	S	
Virginia valeriae Baird and Girard, 1853 Smooth Earthsnake	o			o	P					o						S,P
Introduced reptiles																
Anolis sagrei Cocteau in Duméril and Bibron, 1837 Brown Anole	S			S						S,M,L	S					

	TIMU	CAHA	CALO	CASA	CHAT	CHPI	COSW	CUIS	FOFR	FOMA	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU
Pseudemys nelsoni Carr, 1938 Florida Redbellied Cooter					S											
Trachemys scripta (Schoepf, 1792) Pond Slider	S															
Hemidactylus garnotii Duméril and Bibron, 1836 IndoPacific Gecko										M,L						
Hemidactylus turcicus (Linnaeus, 1758) Mediterranean House Gecko									M,L							
Phrynosoma cornutum (Harlan, 1825) Texas Horned Lizard	M															

[1]Reported historically, not found in contemporary surveys.
[2]Reported only from Wright Brothers National Memorial, Kill Devil Hills, Bodie Island; apparently not established within park boundaries at other sites.
[3]Reported only from Ft. Raleigh National Historic site on Roanoke Island; apparently not established within park boundaries on Hatteras, Bodie, or Ocracoke Islands.
[4]Reported only from NPS land on Harker's Island; apparently not established on Shackleford or Core Banks.
[5]Reported by Hillestad et al. (1975); not found in contemporary surveys and believed to be erroneous by Shoop and Ruckdeschel (2000).
[6]Individuals occasionally reported from the park, almost certainly not a resident population.
[7]Suspected to be an introduced species.
[8]Historically reported, we and the NPS (1977; Management Report No. 22) find no evidence that these species still exist within park boundaries.
[9]Report (Quay 1959) is believed to be erroneous by several authorities; we found no evidence that the species is present within the park today.
[10]Apparently only known from Little Cumberland Island (Shoop and Ruckdeschel 2000).

Appendix 4. Summary of herpetofaunal surveys of the National Park Service's Southeast Coast Network. Full names for parks are provided in Figure 1 and Appendix 1. TIMU includes Ft. Caroline National Monument; FOSU includes Fort Moultrie National Monument; CAHA includes Wright Brothers National Memorial and Fort Raleigh National Historic Site.

	TIMU	CAHA	CALO	CASA	CHAT	CHPI	COSW	CUIS	FOFR	FOMA	FOPU	FOSU	HOBE	KEMO	MOCR	OCMU
Park size (ha)	3462	14,282	10,192	8	1847	11	8621	7631	97	121	2,172	79	826	1166	36	284
# native species documented	60	48	35	3	62	8	61	64	20	26	24	8	61	43	49	55
% within range native species documented	61.2	48.5	34.7	3.1	77.5	7.6	59.8	61.0	19.0	26.5	21.1	7.4	58.7	55.1	50.5	58.5
# introduced species	4	0	0	3	1	0	0	0	1	5	1	0	0	0	0	0
Herpetofaunal assemblage composition (% of total number of native species documented)																
Anurans	25	23	23	67	19	25	34	23	25	23	29	50	30	23	37	29
Salamanders	8	6	6	0	18	13	13	8	0	0	4	0	18	26	12	15
Crocodilians	2	2	0	0	0	0	2	2	5	0	4	0	0	0	0	2
Turtles	17	23	26	0	15	0	11	22	10	23	13	0	13	12	12	13
Lizards	13	13	14	0	15	50	8	16	25	19	17	25	13	9	14	13
Snakes	35	33	31	33	34	13	31	30	35	35	33	25	26	30	24	29
Survey technique effectiveness (number of species documented by method)																
SREL field surveys	44	21	13	6	43	8	52	8	19	11	15	8	48	28	46	50
Museum specimens	22	38	30	0	20	0	0	44	2	26	7	0	7	8	2	2
Literature records	0	46	27	0	0	0	43	64	0	30	21	0	3	1	0	2
Pers. communications	16	0	1	0	62	0	4	0	1	0	0	0	41	37	1	31