The Ecological Impact of Man on the South Florida Herpetofauna

Larry David Wilson
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The University of Kansas
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Price for this number: $7.00 postpaid

Published in cooperation with
WORLD WILDLIFE FUND-U.S.

Front cover: An adult giant toad (*Bufo marinus*) in an urban South Florida setting. Photograph © 1983 by Jim Bridges.

University of Kansas
Museum of Natural History

Special Publication No. 9

8 August 1983

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Lawrence
1983

UNIVERSITY OF KANSAS PUBLICATIONS
MUSEUM OF NATURAL HISTORY

Editor: JOSEPH T. COLLINS

Special Publication No. 9
pp. i–vi; 1–000; 35 figures
4 tables; 1 appendix
Published 8 August 1983

PRINTED BY
ALLEN PRESS, INC
LAWRENCE, KANSAS 66044

ISBN 89338-018-0

FOREWORD

In the late 1950's I encountered my first inkling of the amount of biological change being wrought in South Florida. It came from comparing the plastic neon strip of Palm Beach south to Miami with the watercolors and impressions of my grandfather Leon Gillette who, in the '30's, held a number of architectural commissions there. Yet I was too young to realize all the adverse change, and indeed a lot of it remained generally undiscerned.

The alteration during the subsequent 25 years has almost dwarfed that which came before. Yet I don't think I ever truly appreciated the extent of environmental modification, until recently, when my attention was drawn to a slim, privately printed volume by John Kunkel Small, the pioneering botanist of the flora of the southeastern states. *From Eden to Sahara: Florida's Tragedy* is illustrated with photographs of Florida's vegetation from the early part of the century. Part is a Florida that most people will never see. Part is a Florida that will never be seen again. How frightening it is that so much ecological and biotic change can take place with it scarcely attracting attention or tweaking curiosity.

In a sense, the South Florida story is representative of such change on a global scale. There is massive habitat destruction, dramatic overuse of pesticides, major disruption of ecological systems, in particular, massive alteration of the south Florida water table even to the point of possible climatic change. In addition, there is, probably to an extent greater than anywhere else in the contiguous United States, the impact of alien species. This latter makes this situation of particular interest.

The species that loom largest in this story are the introduced plants, three terrestrial and two aquatic. They, almost as much, if not more than urbanization, create homogenized landscapes unsupportive of much of the native fauna. An interesting aspect of this study is that in comparison to plants, for example, competition from alien herpetofauna apparently has little affect on the native species. In comparison, habitat destruction and the simplification of habitats by these introduced plants appears to have played a major role. Where foreign fauna have been successful and the native fauna has waned, more often than not the causal factor appears to be habitat change; the natives vacate the barrio, and only then do the new arrivals move into the vacated space.

An account of such profound environmental change as this inevitably engenders renewed emphasis on the task of environmental protection. The indiscriminate use of chemicals, the substantial alteration of south Florida hydrology, and the impact of some of the introduced species render that task exceedingly difficult, but hopefully not to the point of discouraging appropriate agencies both public and private. Yet, to a major extent in all instances and almost entirely so in the case of the herpetofauna, these are the real problems, and conservation cannot succeed in the end without facing them.

When I was first getting deeply imbued in natural history I was attending a school of which a major benefactor had been the very Henry Flagler whose East Coast Florida railroad made possible some of the early development. It would be unfair, I think, to lay the blame at his door, for clearly there was a growing pressure for development far larger than his particular initiative. Indeed the bulk of the destruction came long after, and part of Flagler's motivation must have been to bring people to the world of the palmetto and the Barefoot Mailman, not to destroy it. In fact, presiding as a trustee, as he did, over a school where matters biological received their proper due, I can only think that he would indeed be horrified by the ecological change of the Florida of today, and take some pleasure that a student of that school, about which he cared so much, should have the opportunity to provide a foreward to this work.

Thomas E. Lovejoy
World Wildlife Fund
Washington, D.C.
Washington's Birthday 1983

PREFACE

The picture we paint for the herpetofauna of south Florida in this paper is, in some ways, peculiar to this area, but it is also illustrative of the kinds of effects which increasing urbanization and manipulation of the environment can have, wherever they may occur. Few areas of the United States are likely to have the exotic herpetofaunal load that currently exists in south Florida, but many parts of the country are now feeling, or will soon begin to feel, the pressure on the natural environment resulting from rapid population growth. South Florida has been the focus for unparalleled growth for much of its recent history, but several other regions, especially in the Sun Belt, are now vying for the dubious honor of attaining the highest growth rate in the nation. Thus, although we are writing about man's impact on the herpetofauna of a small and, to some extent, unique area, much of what you will read in the remainder of this paper will, we think, have distressingly familiar overtones.

Larry David Wilson and Louis Porras
Miami, Florida
May 1981

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INTRODUCTION

During the many years we have lived in south Florida we have been keenly interested in the composition, distribution, and status of introduced amphibians and reptiles in this area. Several years ago we became aware of certain additions to the area's exotic component of the herpetofauna and began to prepare a report on them. As we gathered data it gradually became apparent that instead of simply reporting the additions, there was a need to summarize the existing data on the entire introduced herpetofauna, with special reference to its impact on native amphibians and reptiles. As we progressed, some of the additions we intended to include were reported elsewhere (e.g., *Anolis cristatellus, Anolis garmani,* and *Ctenosaura pectinata*—the latter misidentified as *C. similis*). In addition, it also became apparent that we would only tell a portion of the story if we were to restrict our coverage to the exotic herpetofauna and its impact on the native one. We soon saw the need to adopt a broader perspective and to examine the sum total of man's activities in south Florida as they relate to the ecological status of both the introduced and indigenous segments of the herpetofauna. This then is the subject of this paper.

In 1958 Duellman and Schwartz wrote a classic paper on the amphibians and reptiles of south Florida. In that work they summarized the available information on the south Florida herpetofauna, most of which was stored in numerous short papers of limited scope, and they considerably augmented these data as a result of their own extensive field work. Since the publication of the Duellman and Schwartz paper, numerous others of limited scope dealing with the native and introduced members of the south Florida herpetofauna have appeared, but the only subsequent comprehensive work to appear was that of King and Krakauer (1966), which summarized the available information on the entire exotic component of the herpetofauna.

There is now a need for an extensive update. First, many changes have occurred with respect to the indigenous herpetofauna since the publication of the Duellman and Schwartz paper. Secondly, there is much new information on the status of populations of exotic species, and additional species have become established since the publication of King and Krakauer's paper. Finally, we have written this paper because we have a different point of view from that expressed in most of the literature on south Florida's introduced amphibians and reptiles.

We feel qualified to consider the ecological impact of man on the south Florida herpetofauna, both native and exotic, for several reasons. First, one of us has resided in the area since 1955[1] and the

[1] The second author moved to Utah in September 1982.

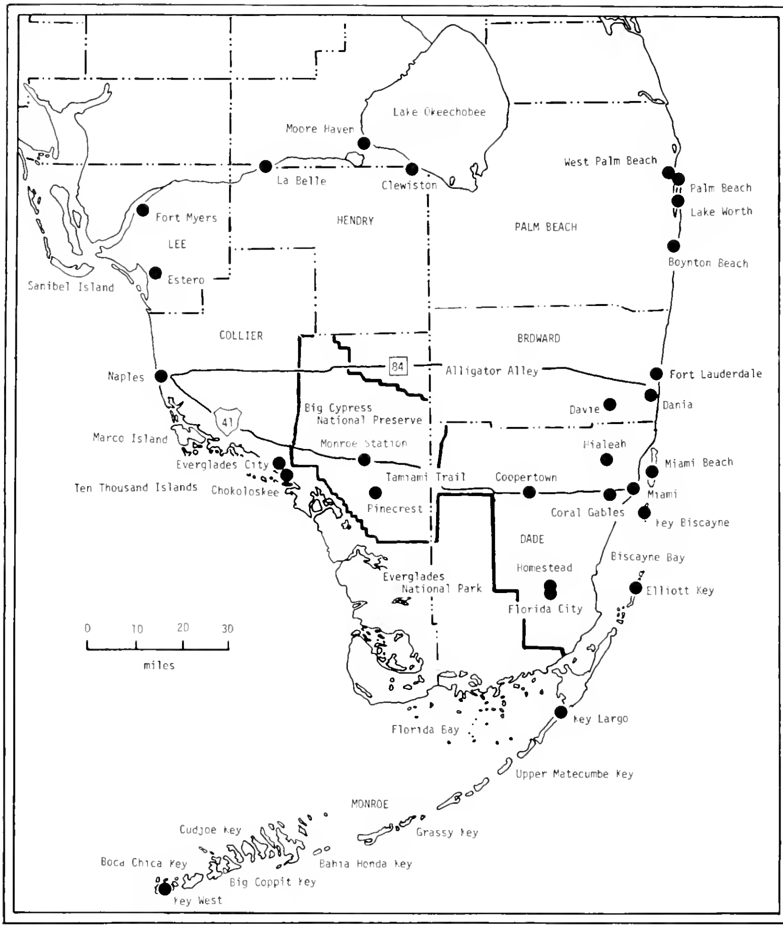

FIGURE 1. Map of south Florida showing principle localities mentioned in text.

other since 1971, a combined total of 38 years. Secondly, over the course of this time, we have been in contact with the broad spectrum of the herpetological community of south Florida. Of particular importance is the fact that one of us (LP) has been involved in the animal trade since childhood, being in continual contact, therefore, with the majority of the area's animal dealers, professional collectors, and amateur enthusiasts, and in addition, has spent considerable time in the field. The other author (LDW) has taught environmental science courses for several years, emphasizing the human role in the ecology of the area. For the past several years we have been collaborating on numerous research projects focusing on the herpetofauna of Latin America and the American Southwest, but since we are both avid field biologists we have traveled and worked extensively throughout the southern portion of the Florida peninsula. During this time we have been actively gathering data relating to the problems discussed above.

The scope of our study area has been expanded beyond that of Duellman and Schwartz. Those authors included the area of the peninsula south of a line between Fort Lauderdale and Naples (more or less the path now followed by Florida Route 84, or Alligator Alley). We consider south Florida (Fig. 1) to consist essentially of the area south of the southern part of Lake Okeechobee, or the counties of Broward, Collier, Dade, Hendry, Lee, Monroe, and Palm Beach. We have done so because we believe a better overview is afforded by a consideration of the larger area.

Following the reasoning of Duellman and Schwartz, we also have deleted consideration of the species of marine turtles occurring in Florida waters. In discussing the native herpetofauna, we have omitted records which we consider questionable.

Voucher specimens documenting most of the new introductions and/or new populations of exotic species have been placed in the Louisiana State University Museum of Zoology and the Florida State Museum collections.

We acknowledge that some of our sources of data are anecdotal, but they are important in obtaining an historical perspective. The south Florida described by Carr (1940), Barbour (1944), and even Duellman and Schwartz (1958) is now only a memory. We are hopeful, however, that our efforts will provide an incentive for future workers to conduct even more detailed studies on the ecological relationships of both the native and exotic amphibians and reptiles of this area.

ACKNOWLEDGEMENTS

We can never hope to adequately acknowledge, in a paper of this nature, all of the people who have contributed their assistance. The work began, for one of us (LP), almost twenty years ago when he had the opportunity to care for amphibians and reptiles at a wildlife compound owned by Charles P. Chase. A few years later, during the heyday of the South Florida Herpetological Society, the field work of some of the members provided a continuous stream of information about south Florida's amphibians and reptiles. Field enthusiasm was then sparked, in large part, by the zealous collecting efforts of the late William Tudor.

We began serious work toward the preparation of this paper in 1973. Since then, we have received help from a large number of friends and colleagues. For the provision of information, donation or loan of specimens, and/or field assistance, we would like to thank the following: Ray E. Ashton, Jr., Robert Bader, Lawrence G. Bailey, Tim Barken, Arthur G. Bass, Scott Bazemore, Bruce Bednar, John Boursot, Robert Bush, Jonathan A. Campbell, Edward Chapman, Ralph Cramer, George H. Dalrymple, Jeff Doyle, Tamir Ellis, Richard S. Funk, Richter A. Gideon, James L. Glenn, Ted Greenwald, Scott Hearsey, Michael Heinrichs, David Hewett, Tom R. Johnson, Howard E. Lawler, Robert Lawton, Julian C. Lee, Greg Longhurst, RobRoy MacInnes, John A. Mascarello, Carl May, Regis McDermott, Roy McDiarmid, Brian Mealey, Peter Meylan, Paul E. Moler, Ann Ramus, Eugene R. Robinett, Gordon W. Schuett, Ben Simonetti, Joseph Terry, Raymond Van Nostrand, C. Rhea Warren, Joseph Wasilewski, William Ziegler, and John Zura.

We are grateful to Jim Bridges and John Rindfleish for providing information and for the use of photographs,* and to Arthur C. Echternacht for examining specimens of *Ameiva.* Joseph Beraducci was especially helpful in providing us with information, specimens, and field assistance.

For critically reviewing the manuscript and numerous other courtesies we are especially indebted to Joseph T. Collins, William E. Duellman, Philip S. Humphrey, James R. McCranie, Lewis D. Ober, Gordon W. Schuett, and Albert Schwartz. Roger Conant was of indispensable aid in improving the manuscript, working long hours on its editing even while in the field in Costa Rica. He also kindly supplied us with photographs of three exotic species taken by his late wife Isabelle.

Our wives, Elizabeth Wilson and Diane Porras, have been more than patient when our work on this paper at times seemed interminable. Our special thanks go to them.

Finally, we will never forget the encouragement and assistance provided by the late Phil Bennett, a long term friend and field companion of one of us (LP), who generously allowed us to report the existence of a number of introduced species.

THE HISTORICAL ENVIRONMENT

The following summary of the geology, physiography, hydrography, climate, and vegetation of south Florida is necessary in providing a background for a discussion of changes that have occurred in the entire area, in general, and in populations of amphibians and reptiles, in particular, since modern man's intrusion.

Geology.—Geologically speaking, the southern portion of the Florida peninsula is only recently emergent from the sea. About 100,000 years ago the sea level stood 25 feet above its present level,

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* Photographic credits in this book are as follows: Jim Bridges (JB), Isabelle Hunt Conant (IHC), Louis Porras (LP) and John Rindfleish (JR).

and virtually the entire southern portion of the peninsula was under water (Hoffmeister 1974).

Several geological formations occur in south Florida which were discussed and mapped by Duellman and Schwartz (1958) and Hoffmeister (1974). The following summary is based on these two sources. The oldest formation is that of the Tamiami limestone of Miocene age and is best seen in most of Collier County. The Caloosahatchee marl of Pliocene age is visible in most of Hendry County. All the other geological formations (Fort Thompson, Key Largo limestone, Anastasia, Miami limestone, and Palmico sand) are of Pleistocene age and of approximately equivalent geological antiquity, differing from one another principally in the method of formation, having been deposited under different environmental conditions.

Physiography.—The southern portion of the Florida peninsula is basically flat. The highest elevations occur along the Atlantic coastal ridge or eastern rock rim (20 feet, or about 6 meters) and on sand dunes on Marco Island on the western coast (55 feet, or 16.8 meters). Between these areas lie the lowlands of the Everglades and the Big Cypress Swamp. The former slopes gradually toward the sea, forming the broad, flat basin of the Everglades River. Between the Everglades and the Atlantic coastal ridge and above the Big Cypress Swamp lie sandy flatlands, and the southern portion of the peninsula consists of mangrove and coastal glades (Hoffmeister 1974).

Hydrography.—Historically, the surface water drainage patterns in south Florida were rather simple (Fig. 2A). Rain falling on the Kissimmee Basin was channeled into Lake Okeechobee and the sandy flatlands to the southwest. During the wet season occasional spillover from the southern bank of the lake created a water flow which formed a broad, shallow "river" coursing southward to empty into Florida Bay. Water in the Big Cypress Swamp also flowed southward, entering the region of the Ten Thousand Islands. Water also moved westward along the Caloosahatchee River to empty into the Gulf of Mexico. From the sandy flatlands to the east of Lake Okeechobee, water issued into the Everglades, percolating into the aquifer underneath the Atlantic coastal ridge. The surface water of the south Florida peninsula, thus, moved in three directions, viz.: (1) the atmosphere by evapotranspiration; (2) the sea by surface runoff; (3) the underlying aquifer by infiltration. Storage water in the aquifer slowly discharged into the sea (Browder, Littlejohn, and Young 1977).

All of the geological formations in south Florida are fair to excellent aquifers, except for the Tamiami formation (the area of the Big Cypress Swamp). The Biscayne Aquifer underlies southeastern Florida, principally in Broward, Dade, and Monroe counties, gradually increasing in thickness from 10 feet or less in the west to 150 to 200 feet in the east.

Bodies of fresh water in south Florida are limited to cypress ponds, sinkhole ponds, and a few rivers and sloughs.

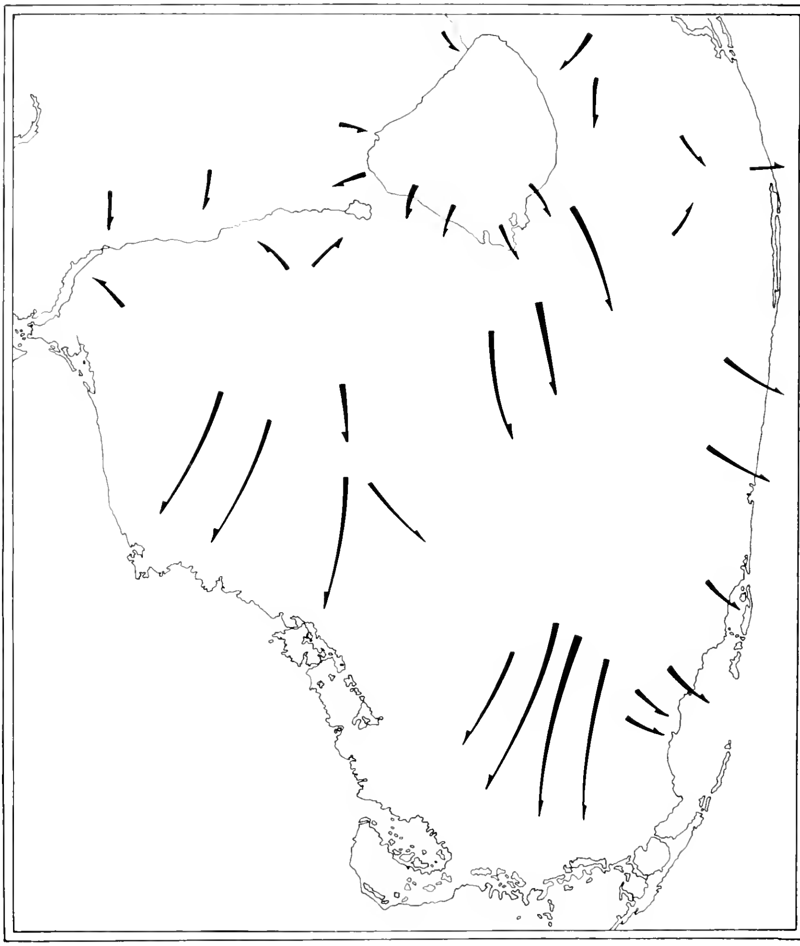

FIGURE 2A. Historical drainage patterns in south Florida.

Climate.—Duellman and Schwartz pointed out that the climate of south Florida is equable, that the summers are hot and rainy and the winters mild with reduced precipitation. They further stated that the heaviest precipitation occurs during September and October, the hurricane season.

Vegetation.—The variety of vegetation types seen in south Florida is primarily a function of edaphic conditions, elevation, frequency of fires, proximity to the shoreline, and, to a lesser extent, the amount of rainfall (Carr 1940; Duellman and Schwartz 1958; Craighead 1971). A simplified discussion of vegetation types, based on these works and our personal field experience is presented below.

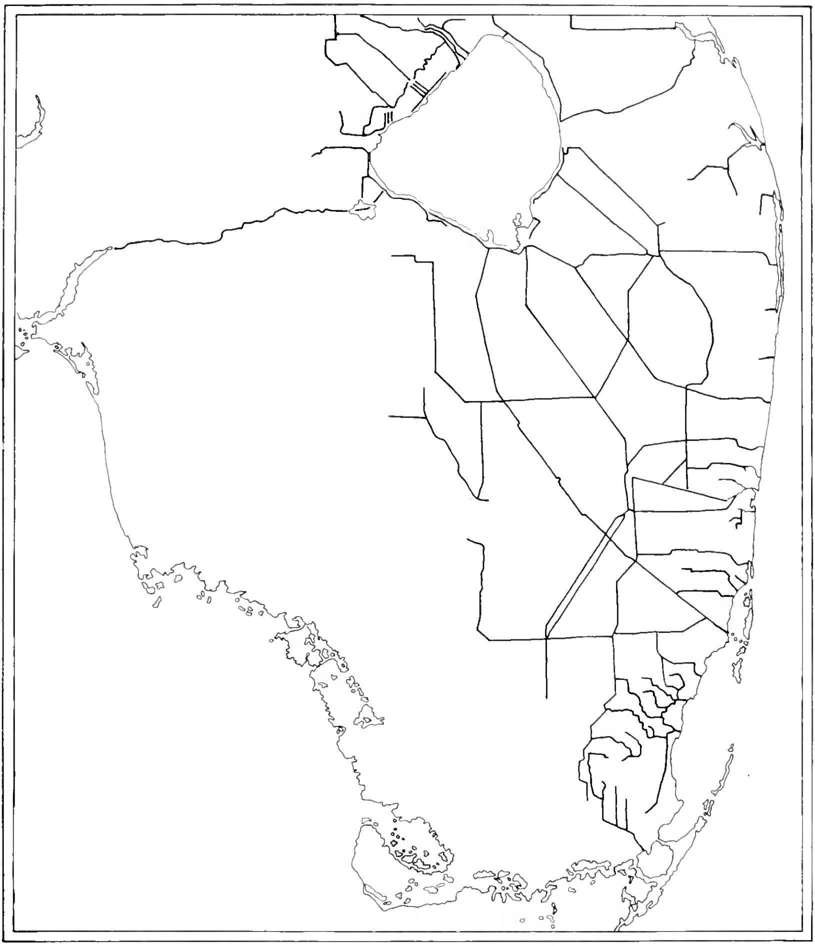

FIGURE 2B. Present-day network of drainage canals in south Florida.

The sandy scrub areas in extreme western Collier and parts of Lee and Hendry counties in the west, and in northern Dade and parts of Broward and Palm Beach counties in the east, occur in slightly elevated areas having a porous, sandy soil and which supports a vegetational cover consisting of sand pine, myrtle oak, and rosemary. Prickly pear and various grasses are found in the understory.

Intermingling with the sandy scrub areas and extending southward along the Atlantic coastal ridge and on the Lower Florida Keys are the pine flatwoods. This vegetational type is more extensive than the rosemary scrub. On the western side of the peninsula, pine flatwoods are present on a sandy soil, whereas in the east they occur on a rocky oolitic limestone substratum, which is often covered with a thin layer of sand. The vegetation consists principally of Caribbean pine, saw palmetto, and silver palm. Wiregrasses, coontie, and prickly pear occur in the understory.

Scattered through the pine flatwoods on the Atlantic coastal ridge in Dade County are the oak hammocks. These hardwood patches develop on elevated, well-drained soils and are characterized by the presence of the dominant tree, live oak. The branches of these trees are covered with airplants, such as various wild pines and Spanish moss.

Another type of hammock in south Florida is the tropical hardwood hammock. Such areas occur in patches along the Atlantic coastal ridge. Some are quite extensive and form tree islands in the Everglades and in elevated areas of the upper Florida Keys. They develop on rocky, oolitic or Key Largo limestone, which often appears at the surface and is extremely pitted with solution holes, some of which are very large, forming sinkholes. The vegetation includes many species of West Indian and Bahamian affinity, among them such trees as strangler fig, mahogany, pigeon plum, mastic, Jamaica dogwood, poisonwood, lignum vitae, gumbo-limbo, wild tamarind, sargeant palm, thatch palm, and manchineel. The limbs and trunks of the trees are covered with various species of bromeliads, orchids, peperomias, and lichens. The understory consists of various species of stoppers, wild coffee, and various ferns.

In the low interior catch basin of the southern portion of the peninsula are the freshwater marshes known as the Everglades. Most of that area is occupied by prairies in which the dominant plant is the sedge commonly called sawgrass. The area is dotted by tree islands composed of varying species associations and is bounded on the east and west by poverty-grass prairies. The tree islands may be bayheads, willow heads, tropical hardwood hammocks, cypress domes, cabbage palm hammocks, or saw palmetto rings.

West of the Everglades and occupying much of Collier County, lies the Big Cypress Swamp. The swamp is dotted with bayheads, pond apple swamps, and pop ash domes. Higher areas support palmetto thickets, Caribbean pine, and some hardwoods.

Along the coastal areas of the southern tip of the peninsula are scattered salt marshes, which occur as a transitional area between the freshwater and mangrove swamps. They support growths of low, herbaceous halophitic plants such as black rush, saltwort, saltbush, saltgrass, prickly cord grass, and samphire.

Extensive areas along the coast are covered with mangrove swamps. The dominant plants are red mangrove, black mangrove, and white mangrove (occurring in that order from open water to the inland limits of such swamps). Buttonwood is also common on the more elevated areas.

Sandy beach areas are backed by coconut palms, sea grape trees, and sea oats, with the ubiquitous sand spurs underfoot. Railroad vine grows outward over the open beaches.

THE PRESENT-DAY ENVIRONMENT

South Florida has undergone staggering environmental changes within a relatively short span of time. The changes have primarily resulted from the dramatic increase of the human population in the area. Here we discuss settlement patterns and changes that have occurred in hydrography, climate, and vegetation, as a preface to an examination of the impact of these changes on the area's amphibians and reptiles.

Settlement patterns.—The peculiarities of the physiography of south Florida have played a decisive role in the pattern of human settlement. Key West, at the terminus of the chain of islands that comprises the Florida Keys, was an early center, primarily because of its strategic position for shipping and military purposes and the relative inhospitability of the mainland. Population grew from 517 in 1830 to 17,114 at the turn of the century (Browne 1973). Settlement of the mainland was inevitable, however, and the areas first occupied were those that were relatively high and dry, viz., the Atlantic coastal ridge and later the sandy flatland coastal area from the mouth of the Caloosahatchee River south to the beginning of the coastal zone near present-day Naples. Settlement proceeded most rapidly along the Atlantic coastal ridge. Dade County was established in 1836 and by 1890 its population was 861 (Hollingsworth 1949). By 1896 Henry Flagler had brought his Florida East Coast Railroad to Miami and by 1900 the population had mushroomed to almost 5000 (Hollingsworth 1949; Tebeau 1966). On the west coast the relatively high, flat terrain attracted cattle ranchers to the Caloosahatchee River area, the site of a fortification used during the Seminole Indian wars.

The population of Dade County has always advanced ahead of other areas of mainland south Florida. Between 1900 and 1920 it increased from 4955 to 42,753. Three years later the beginning of the first Florida land boom brought unprecedented growth to southeast Florida, and during the boom years of 1924–1926 Miami "was transformed from a sleepy little town on the edge of Biscayne Bay into a Magic City of modest skyscrapers and legendary real estate profits" (Ballinger 1936). The boom, which had been statewide, but centered on Miami, came to an abrupt halt when a hurricane struck the city in September 16, 1926 (Tebeau 1971). Even though another hit Palm Beach on the same day two years later, growth continued and by 1935 the population had increased more than fourfold. Between 1935 and the present, growth has continued along the Atlantic coastal ridge, and today a megalopolis exists stretching for almost 100 airline miles from West Palm Beach to Florida City.

Growth along the west coast south of the Caloosahatchee River has been modest compared to that of the east. Troubles with the Seminoles prompted the building of Fort Myers near the mouth of the river in 1850. After the Civil War the area became a thriving agricultural region, and the city of Fort Myers was incorporated in 1885. Lee County, which then encompassed all of the present-day Hendry and Collier counties, was created in 1887. Naples was started in 1876 and incorporated in 1923. Estero was founded in 1894.

The Ten Thousand Islands area remains unpopulated even to the present day, inasmuch as it consists of several thousand small mangrove islands. Only Chokoloskee and Everglades City exist as small outposts.

The interior of the southern portion of the peninsula has remained sparsely populated. Only La Belle, Immokalee, and a string of small towns around the southern and western borders of Lake Okeechobee (Belle Glade, Clewiston, and Moore Haven) exist as centers of population in this farming and ranching area of south Florida.

In 1912 the Florida East Coast Railroad reached Key West, connecting the Florida Keys with the mainland. The Labor Day hurricane of 1935, however, destroyed the Keys extension of the railroad, but three years later the overseas highway was built utilizing long spans of the former railroad bed. Since then, people have occupied the length of the Keys, which is fast becoming a pencil-thin megalopolis.

Changes in hydrography.—The history of water management in south Florida has been one of modification of the hydrography for human benefit at the expense of nature's (Fig. 2B). Water management in the area has passed through three major stages. Prior to 1900 portions of the Kissimmee and Caloosahatchee rivers were dredged for navigational purposes, and minor efforts toward drainage for development were made. During the period from 1900 to 1953 numerous uncontrolled canals were built for the express purpose of draining the Everglades to the Atlantic, i.e., to remove large amounts of "excess" wet season fresh water in order to open up land for development. Whereas these efforts were successful in reducing the water storage capacity of the area, flooding of urban areas still occurred, so in 1948 the Central and Southern Florida Flood Control District was created to "(1) reduce the flooding in the urbanized east coast, (2) further protect and enhance the Everglades Agricultural Area farm production, (3) reclaim thousands of acres of wetlands for agricultural and urban use, and (4) form water conservation areas in the Central Glades to store water for recharge of the Biscayne Aquifer and for supply to Everglades National Park" (Browder, Littlejohn, and Young 1977).

These objectives have been achieved but not without massive alterations in the natural systems of south Florida. Among the mostly detrimental effects are: (1) reduction of the storage capacity of the system, severely decreasing the amount of holdover of wet season water to meet dry season needs; (2) increase in loss of fresh water to the sea; (3) increase in the severity of droughts, extent of salt water intrusion, and frequency of fires; (4) eutrophication of Lake Okeechobee; (5) creation of more distinct but smaller storage units; (6) intensification of dependence on energy intensive technology to solve water management problems (Browder, Littlejohn, and Young 1977). These effects continue to the present day.

Climatic changes.—Historically, south Florida received about 75% of its rainfall during the six wet season months from May through October, a rainfall pattern typical of tropical areas to the south. The resulting freshwater was held in the Kissimmee-Okeechobee-Everglades catchment basin to moderate drought during the dry-season months. However, south Florida has experienced several droughts since the dry-season of 1970–1971, and each was severe enough to rank with the worst during the previous hundred years. Furthermore, predictions of future world weather patterns suggest that south Florida may be entering a dry period of approximately 30 years duration (Fairbridge 1974; Browder, Littlejohn, and Young 1977). It can be expected that the dry season effects, enhanced by the water management practices in south Florida, will be intensified. Such changes will be aggravated, by an increasing demand for water by the burgeoning south Florida population.

On the other hand, the rainy season of 1979 began with a violent rainstorm that left vast areas of southeastern Florida flooded. Expansion of concrete and asphalt-covered areas made runoff and percolation more difficult. The flooding that occurred in 1979, however, probably will not seriously affect overall drying trends. The extremely dry spring of 1981, with the driest April in recorded history, would seem to bear that out, but the heavy rainfall in the fall left areas of the East Everglades flooded.

Another climatic change of interest is the absence of tropical cyclones or hurricanes affecting south Florida in recent years. In the 102 hurricane seasons recorded since 1878, 42 tropical cyclones affected the Miami area, or an average of one every 2.4 years. Thirteen of the storms developed hurricane force winds, or one every 7.8 years. Major hurricanes occurred during 1926 (the one that killed the Florida land boom), 1945, 1950, 1960 (Donna), 1964 (Cleo), and 1965 (Betsy). During the 1979 season, the Miami area was threatened by Hurricane David, but the threat did not materialize. The 1980 season was the fourteenth consecutive one in which no tropical storm affected the Miami area, an all time record. The previous one was the six year period from 1954 through 1959 (Merrill 1977). In 1981, Tropical Storm Dennis passed over south Florida dumping large amounts of rain, but producing minimal winds. South Florida is long overdue for a big one.

Temperatures at or below freezing are of infrequent occurrence in most of the south Florida area. In January 1977 temperatures dropped below freezing and snow fell for the first time in recorded history in Miami. It is suspected that the freezing temperatures were the reason for the apparent disappearance of at least one exotic species of amphibian from south Florida. In January 1981 the temperature again fell below freezing on two occasions, and in January 1982 once.

Vegetational changes.—The subtropical character of the natural vegetational associations in south Florida is a unique feature of the area. Key West is only 30 miles north of the Tropic of Cancer. Consequently, Florida enjoys a climate favorable to the growth of many tropical species of plants. As a result of human activities, however, the nature of the vegetation in the area is changing rapidly and, seemingly, irrevocably. The major factors involved in bringing about these changes are several, viz.: (1) destruction of primary vegetation to make way for buildings and agricultural fields; (2) introduction and subsequent release of various exotic plants; (3) man-generated fires; (4) changes in water supply; (5) use of native trees for lumber.

Destruction of the primary vegetation in the wake of human expansion into the area has continued apace. Since the major settlement of south Florida has occurred along the coastal areas, it is those areas that have been most heavily affected. The relatively elevated areas of the Atlantic coastal ridge historically harbored extensive stretches of pine flatlands interspersed with hardwood hammocks and patches of sandy scrub. It was precisely because of the elevated and well-drained nature of these areas that early settlers were attracted to the region. The land was used for homesites and has continued to attract developers.

According to data provided in the South Florida Study (Browder, Littlejohn, and Young 1977), 32.9 percent of the area they surveyed (they included the Kissimmee River basin, which lies north of our area) has been given over to urban and agricultural development. Their study divided the natural areas into uplands, wetlands, coastal systems, and estuarine/marine systems. Among these subsystems, those most adversely affected by human intrusion have been the uplands and wetlands. In 1900, the uplands and wetlands constituted 33.0 and 54.7 percent of the total area of south Florida, respectively. By 1973 the figures had dropped to 18.3 and 36.8 percent. Within the uplands subsystem the areas most heavily affected (primarily by agriculture) were the wet prairies and sawgrass marshes whose respective percentages fell from 18.7 to 10.3 and 11.4 to 5.5 during the same period. The coastal and estuarine/marine subsystems have remained relatively unaffected by development. Mangrove areas have been cleared for beach development, however, and the acreage occupied by that vegetational type dropped from 606,517 to 589,440 from 1900 to 1973.

Development in the Fort Myers-Naples area has not been so rampant as on the east coast, and relatively undisturbed areas of pine flatwoods are still well in evidence. Nevertheless, the area is rapidly becoming urbanized, and there is no reason to believe that it will not follow the same course as that of the east coast. To the south, Marco Island has been extensively developed as a resort community, especially for retirees.

Even if the spread of human building and agricultural activities were to stop today, it is likely that enormous changes would occur in the vegetation because of the naturalization and dispersal of certain exotic plants. The subtropical nature of south Florida, coupled with the existence of Miami as a port of entry into the United States, has meant that the area has long acted as a funnel for the movement of tropical plants into this country. The mild climate has permitted the establishment of numerous nurseries and botanical gardens for the propagation of such plants, and some of these outlets have played an important role in the introduction of exotic plants into the area.

As a result of a number of early accidental and planned introductions, some plants, now known to be ecologically detrimental, have become naturalized and have spread rapidly in the area. Five such plants, three terrestrial and two aquatic, are generating the most environmental concern. These are Australian pine (*Casuarina equisetifolia* and two other less common members of the genus), Brazilian pepper (*Schinus terebinthifolius*), paperbark, cajeput or melaleuca (*Melaleuca quinquenervia*), water hyacinth (*Eichhornia crassipes*), and hydrilla (*Hydrilla verticillata*).

Of the three trees, *Melaleuca* poses the greatest threat. Pritchard (1976) recently noted that "*Melaleuca* must be considered the prime ecological problem in south Florida today." Whereas this may be somewhat of an overstatement, the spread of the paperbark tree undoubtedly poses a grave environmental threat. It was introduced into south Florida on both coasts during the early 1900's and became naturalized within about a decade; during the 1930's seeds were spread into the sawgrass prairies of central and western Broward County in an effort to "reclaim the useless swamp" (Pritchard 1976; Austin *in* Morris 1977). This species requires considerable water for growth, and it tends to dry out the land. The seeds are wind-dispersed and will sprout in damp places or even under water. It is an aggressive invader of disturbed areas, and will also penetrate undisturbed areas. The seedlings are able to grow very densely (900 per square meter in some cases) so as to exclude other species (Pritchard 1976). The paperbark tree is dispersing rapidly into the Everglades and "infestation is particularly severe in conservation area 28, inland from Ft. Lauderdale, where some estimates suggest that as much as 40 percent

FIGURE 3. Dense, impenetrable stand of melaleuca along the Homestead extension of the Florida Turnpike near the Broward-Dade county line. (LP)

of the area is covered with melaleuca" (Pritchard 1976). It is also growing densely in Dade County in the vicinity of the Homestead extension of the Florida Turnpike, from which it is spreading westward into the Everglades (Fig. 3). Melaleuca is an extremely hardy tree and difficult to eradicate. Mechanical or fire damage will cause liberation of the seeds to the wind. Cutting the tree down will cause it to sprout anew from the stump and also the fallen trunk. Research is now underway to find ways to control its spread, but thus far mechanical removal and direct application of herbicides seem to be the only effective methods.

Australian pine was originally introduced into south Florida by settlers in the late 1800's. It is a "seashore tree of Australia and the tropical West Pacific" (Austin *in* Morris 1977), and it tends to occur in similar areas in south Florida except where planted. It produces seeds freely which are wind-dispersed, and the tree will also resprout from its stump. *Casuarina* aggressively invades coastal areas scarified by humans and will form dense stands (Fig. 4). It constantly sheds its jointed, green stems which produce phytotoxic substances that retard the growth of other plants in their shade. "The roots form thick mats down to the high tide line, interfering with suitable nesting sites for such endangered species as the American Crocodile and the Green Sea Turtle" (Austin *in* Morris 1977). Because coconut palms were struck by the lethal yellowing blight and have disappeared in many areas of south Florida, Australian pines now dominate the skyline of Miami. Large areas of coastal south Florida,

FIGURE 4. "Takeover" of the shoreline by *Casuarina* at Cape Florida State Park on Key Biscayne, Dade County. Most native vegetation has been crowded out by the Australian pines. (LP)

particularly in Dade County, have been completely taken over by this tree.

Another troublesome tree is the Brazilian pepper. Austin (*in* Morris 1977) pointed out that the date of its introduction is not known, "but it has become a noticeable part of the Florida flora only since about 1950." Its red berries are eaten, and the seeds are dispersed by birds. It occurs in a wide variety of habitats, especially in areas disturbed by humans. Cutting the tree encourages a more disordered growth from the trunk. In areas where it has become well-established, the wild and tangled growth of its branches produces dense shade in the understory that retards the growth of all but the most shade-tolerant plants (e.g., certain species of ferns). *Schinus* is extremely fast-growing and can take over an area in a relatively short span of time, presumably before normal successional changes can bring about a seral stage that could effectively compete for the space (Fig. 5).

Two aquatic weeds are causing both ecological and economic problems in south Florida. One is the water hyacinth, which is now widespread throughout the southeastern United States. The water hyacinth, a native of Brazil, was introduced into the St. John's River at Jacksonville, whence it has spread widely in Florida, clogging waterways due to its rapid growth (Fig. 6). Gore (1976) noted that

FIGURE 5. Brazilian pepper (*Schinus terebinthifolius*) is so abundant throughout southeastern Florida that it is widely considered native and labelled "Florida holly." (LP)

FIGURE 6. Waterway in northern Hendry County so blanketed with water hyacinths as to appear to be solid land. (LP)

FIGURE 7. Regrowth of hydrilla in a recently-dredged canal. Continued removal is necessary to prevent clogging of waterways. (LP)

"today water hyacinths blanket as many as 200,000 acres of Florida canals and lakes," which together with the even more prolific hydrilla "cost at least 15 million dollars a year to combat."

Hydrilla may eventually cause more problems than water hyacinths. The plant was imported into Dade County for aquarium use in the 1950's and became introduced into waterways in 1959 (Austin *in* Morris 1977). Its rapid growth (an inch a day) allows it to blanket an area quickly (Fig. 7). It also spreads easily by becoming attached to "boat propellers, bird's feet, and other objects that move from lake to lake. . . . Consequently, in only a few years it has clogged some 150,000 acres of waterways, and has moved into most other southern states. So far it has been found as far north as Iowa, and biologists fully expect it to spread throughout the country" (Gore 1976).

Only a minor fraction of the introduced plants growing in south Florida have become escapees, but these few have combined to create grave environmental problems. They are all characterized by rapid growth, which interrupts normal successional patterns. The two aquatic weeds can reproduce vegetatively. The three trees have efficient means of seed dispersal, some are self-seeding, and all can sprout from the cut trunk.

Another factor that causes vegetational change in south Florida is the increased frequency of fires due to the reduction of the water storage capacity of the Kissimmee-Okeechobee-Everglades system.

Extensive fires during May 1971 burned more than half a million acres before being quenched by the late summer and fall rains (Ward 1972). Continued fires make way for the advance of the fire-resistant melaleuca and burn the muck in the sawgrass glades, exposing the pitted oolite underneath (Gore 1976).

The cutting of trees (especially pine and cypress) for homesites, lumber, landscaping mulch, furniture, and ornaments is a further problem.

THE SOUTH FLORIDA POPULATION EXPLOSION

Population growth in south Florida during the relatively brief history of modern human involvement has been dramatic and unprecedented with respect to the remainder of the state. In fact, "south Florida is the fastest growing region in the second fastest growing state in the nation" (Florida Regional Coastal Zone Population Analysis 1976).

Compared with other states east of the Mississippi River, Florida is a relatively young one. Only West Virginia and Wisconsin achieved statehood later. Tremendous growth and a marked shift in population center from north to south have occurred in the 136 years since statehood. In 1830 only 517 people lived in Monroe County which encompassed an area slightly larger than south Florida. That population constituted only about 1.5% of the total for the state. By 1860 south Florida had a population of 3014 or 2.15% of the state's total. At that time four-fifths of the population was restricted to the tier of counties along the Alabama and Georgia state lines (Dietrich *in* Morris 1979). In 1860 most of the people in south Florida lived in Key West (2832) and only 83 people lived in Dade County (Anonymous 1978).

After the turn of the century, when the population was 528,542, Florida was growing "steadily but not spectacularly" (Tebeau, 1971). Between the decade of 1910–1920 and that of 1920–1930 the percent of population change went from 28.7 to 51.6 and the population of the state almost doubled between 1910 and 1930 from 752,619 to 1,468,211 (Dietrich *in* Morris 1979), principally as a result of the Florida land boom. Near the beginning of World War II in 1940, the total population of the state was 1,897,414, a relatively modest percentage increase of 29.2 over the 1930 level. The south Florida portion of that total, however, had risen to 429,427 or 22.6%. Since 1940 the percentage of the state's total that is made up by south Florida's populace has grown steadily, as follows: 1950—27.4%; 1960—32.8%; 1970—36.0%; 1980 estimate—36.8%. By the year 2000 it is estimated that the percentage will reach 37.3. By the beginning of the twenty-first century it is estimated that one of every

2.68 people in Florida will live in south Florida, an area comprising only 19% of the state (Thompson 1977).

In 1830 the population of Florida was entirely rural; there were no cities (places with a population of 2500 or more). By 1860 Florida had acquired two cities, Pensacola (2876) and Key West (2832). In 1910 Jacksonville became the largest city in the state (28,249) with Pensacola (17,747), Key West (17,144), and Tampa (15,839) following in that order (Tebeau 1971). By 1920 36.5% of the population was in urban areas and the percentage has continued to rise (1930—51.7%; 1940—55.1%; 1960—73.9%; 1970—80.5%) (data from U.S. Census and the 1977–1978 Florida Handbook).

The reasons for the tremendous population growth during Florida's history, especially since 1950, are several, but they all relate to one major factor, viz., increase in net migration (difference between the number of persons migrating into and out of the state). In 1949 Morris stated that "Florida might be described as a land of large area and few people." At about that time, however, it ranked twentieth among the states in population; in 1970 it ranked ninth (Carter 1974). One report (Florida Estimates of Population, July 1, 1977) indicated that "Florida's population growth during the past quarter century has been little short of spectacular." The same report pointed out that "while the United States population as a whole grew by 42 percent between 1950 and 1977, the Florida population more than tripled, growing from 2,771,305 to 8,717,334." In 1977 Florida was the eighth most populous state. During the 1950's net migration averaged more than 130,000 and almost 250,000 annually during the period of 1970–1977. In the boom years of 1972–1974, net migration into Florida exceeded 380,000 per year. Growth slowed dramatically during the mid-1970's, both in terms of net migration and natural increase, due to rising inflation and economic uncertainty. Nonetheless, during the period from April 1, 1970 to July 1, 1977 the south Florida population rose from 2,444,346 to 3,188,978. Of this increase of 744,632 people, net migration accounted for 704,174 or 94.6% of the total (Florida Estimates of Population, July 1, 1977).

Migration into south Florida primarily has resulted from people flocking there to avoid the cold northern winters and the deteriorating quality of life in some of the larger cities, and also because of Cuban exiles immigrating to escape from Castro's oppressive regime. As a result of the influx of retired people into Florida, the state's natural increase has been declining steadily since the mid-1950's, increasing the median age from 30.9 in 1950 to 32.3 in 1970, whereas that of the United States as a whole during that period dropped from 30.2 to 28.0 (Florida Estimates of Population, July 1, 1977). As noted by Burns (1975), "foreign sources of immigration into Florida increased substantially during the 1960's, principally because of the influx of residents from Cuba. It is conservatively estimated that

TABLE 1. Population increase in the seven south Florida counties (data from Fernald, 1972 and Florida statistical abstract 1967, 1971, and 1977).

Counties	1940	1950	1960	1970	1980 (Est.)[1]	1990 (Est.)[1]	2000 (Est.)[1]	Percentage Increase 1940–1980
Broward	39,794	83,900	333,900	620,100	1,026,000	1,349,200	1,562,100	2478.3
Collier	5102	6500	15,800	38,040	83,800	122,500	141,800	1542.5
Dade	267,739	495,100	935,100	1,267,792	1,525,500	1,782,900	2,064,300	469.8
Hendry	5237	6100	8100	11,859	19,100	24,800	28,700	264.7
Lee	17,488	23,400	54,500	105,216	200,800	279,100	323,100	1048.2
Monroe	14,078	30,000	47,900	52,586	56,000	64,200	74,300	297.8
Palm Beach	79,989	114,700	228,100	348,753	565,200	744,000	861,400	606.6
Totals	429,427	759,700	1,623,400	2,444,346	3,476,400	4,366,700	5,055,700	709.5

[1] Mid-range estimates.

300,000 Cubans settled in Florida (virtually all in the Dade County area) between 1959 and 1972. Foreign immigration into Florida from countries other than Cuba has been fairly insignificant, averaging only about 8000 annually during 1960–1970." The 1970 census indicated that of the 405,036 persons of Spanish origin living in Florida, 250,406 or 61.8% were from Cuba.

South Florida has recently experienced a massive new wave of immigration as a result of the "freedom flotilla" of political refugees from Cuba and the exodus of economic refugees from Haiti. This translocation of people is creating social and economic problems the extent of which is just beginning to be realized.

Population growth in the counties comprising south Florida has been far from even. Between 1940 and 1980, Hendry and Monroe counties have grown relatively slowly; their populations have increased by a factor of 3.6 and 4.0, respectively. Comparable values for Dade (5.7) and Palm Beach (7.1) counties fall below the average factor of increase (10.6). That for Lee County (11.5) falls slightly above the average and that for Broward (25.8) is phenomenal (Table 1).

A cyclical but important factor in population growth in south Florida is the tide of tourists which ebbs and flows through the area. Carter (1974) stated that "an estimated 25 million tourists and other visitors came in 1972, a number fivefold the total of a generation earlier." The 1978 Florida Statistical Abstract indicates that 29,175,000 people visited Florida in 1977. Five of the seven south Florida counties ranked among the top 10 of Florida counties in terms of numbers of visitors absorbed. Dade County ranked second, having received 4,124,000 visitors in 1977, surpassed only by the nearly 5 million visitors to the Orlando area, home of Disney World. However, the five counties of Broward, Collier, Dade, Monroe, and Palm Beach received at least 8,080,000 visitors during 1977. Thus, tourism is a major economic activity of Florida (the 1977 migration put eleven and a quarter billion dollars into the hands of Florida's businessmen or 13.6% of the gross sales for the year) and must be reckoned as a significant source of environmental pressure. During 1977 the monthly average tourist population in Florida was 27.9% of the resident population (data in this paragraph from the 1978 Florida Statistical Abstract). The data speak for themselves.

In recent years, a number of organizations have examined the effects of the increased human population on the area's resource base. One important study is that of Odum and Brown (1975) entitled *Carrying Capacity for Man and Nature in South Florida*. According to Browder, Littlejohn, and Young (1977) four popularized reports were published that were based on the concepts, information, and recommendations of the Odum and Brown technical report. One report was concerned with the entire south Florida area (including the Kissimmee River basin) and the other three with the counties of Collier, Hendry, and Lee. Another important study is

TABLE 2. Land-use patterns in the seven counties of south Florida (data from Florida Regional Coastal Zone Land-Use Analysis, 1976; Southwest Florida Regional Planning Council Land Use Policy Plan, 1978; Brown, *ca.* 1976; Lehman, *ca.* 1976; J. Doyle, pers. comm.).

Counties	Urban	Agricultural	Natural
Broward	47.3	40.3	12.4
Collier	1.5	29.8	68.7
Dade	19.9	8.3	71.8
Hendry	1.6	97.9	0.5
Lee	19.4	15.8	64.8
Monroe	35.1	—[1]	—[1]
Palm Beach	31.3	23.6	45.1

[1] Exact data not available but 64.9% of land falls in a general-use category.

that for the Florida Regional Coastal Zone. Data on the present land-use was included in the above reports and we have used them in the following discussion.

The major land-use categories utilized were three, viz., urban and built-up areas, agricultural areas, and natural cover. The percentage of acreage devoted to each of these uses in the south Florida counties is indicated in Table 2, in which it is evident that the majority of the acreage of south Florida is still in natural cover. About 20% of the total lies within the boundaries of the Everglades National Park, however, which is protected from development. About a quarter of the region is devoted to agriculture (cattle, tree crops, vegetable crops, and sugar cane) and only a small fraction is covered by urban areas. To the uninitiated the area would seem to have much more potential for growth, but such is not the case. The South Florida Study indicated, based on a consideration of the investment ratio for the region (i.e., the ratio of purchased fuel energy to resident natural energy in an area), that "the whole region is at or very near its long-term growth potential" (Browder, Littlejohn, and Young 1977—study completed in 1973).

The recommendations of this landmark study, for all intents and purposes, have been ignored. South Florida's image makers continue to promote the area as a tropical paradise. Population continues to rise in the face of skyrocketing housing costs, increasing interest rates, tightening loan availability, decreasing buying power of wages, increasing racial tensions, a drug-related economy, and a staggering crime rate. Greater Miami is now the metropolitan area with the highest rate of violent crime in the United States. A recent cover article in *Time* magazine summarized the serious problems menacing the area, noting that 125,000 "Marielitos" (=recent Cuban immigrants leaving through the port of Mariel) and 25,000 Haitians have arrived since the spring of 1980 (Kelly 1981). It was estimated in the same article that "Marielitos are believed to be responsible for half of all violent crime in Miami." These problems are so intransigent that President Reagan has appointed a Cabinet-level task force chaired by Vice President Bush to coordinate federal efforts to eliminate South Florida's crime, refugee, and drug-smuggling problems.

South Florida has lost its sheen, the local businessmen are now touting the area as an international trade center, especially for Latin America. Thus continues the sad saga. The *imagined* lure of the "promised land" or "*el dorado*" is too great for the story to be otherwise.

THE METAMORPHOSIS OF THE SOUTH FLORIDA HERPETOFAUNA

In the previous sections we have attempted to describe the major environmental changes that have occurred in the transformation of historical to modern-day south Florida. We have pointed out man-made changes involving most of the major ecological components of the south Florida environment, including the physiography, hydrography, and vegetation. The biological fabric of this region has now become irrevocably transmogrified. The threads of the fabric that constitute the native herpetofauna have been frayed for all time as well. Indeed, twenty-odd years after Duellman and Schwartz remarked that we shall never know what the ecology of the south Florida herpetofauna was like before modern man's intervention, the landscape has become so modified that we must anachronistically look back on that time as an Eden incapable of recapture. The picture of the "vanishing Eden" of Barbour (1944) or Carr (1940) is beyond our mental grasp.

The herpetofauna of present-day south Florida has become a curious mixture of native amphibians and reptiles, both those with stable or declining populations, and variously successful introduced species. South Florida, in fact, has more introduced species of amphibians and reptiles than any other part of the United States (Smith and Kohler 1978; and the present paper), and perhaps more than any area of comparable size in the world. It is the purpose of this section to discuss the effects of the drastic alteration of the south Florida environment on the members of the native herpetofauna and to update the available information on the composition, distribution, and status of the introduced herpetofauna.

The Native Herpetofauna

Before discussing the native amphibians and reptiles of south Florida, it is important to define the word "native" as distinct from the word "introduced." In a sense, if one takes a long view of geological history, the *entire* herpetofauna of south Florida could be viewed as introduced, inasmuch as the southern end of the peninsula (as well as the coastal areas to the north) is only recently emergent from the sea. We use the word "native" for those species of amphibians and reptiles that we believe were living in southern Florida prior to the invasion of the area by modern (i.e., not aboriginal) humans. Our definition of "introduced," therefore, would include those species that appear to have arrived in south Florida through the agency of modern man. It should be noted at this point that it is possible that some of the most obviously successful introduced species (for example, *Eleutherodactylus planirostris, Osteopilus septentrionalis,* and *Anolis sagrai*) probably would have arrived in south Florida on their own by overseas rafting (i.e., not through the agency of humans). Consideration of whether they might have done so or not tends to blur the distinction between the terms "native" and "introduced," so we shall hold to the definitions stated above.

We define these terms somewhat differently than Smith and Kohler (1978), who used a category entitled "exotic differentiated taxa" to include three lizards (*Anolis carolinensis, A. distichus floridanus,* and *Sphaerodactylus n. notatus*), which they stated were "taxa that have differentiated sufficiently since introduction to be regarded as different, subspecifically or specifically, from the parent population." Consideration of such taxa as "introduced" is to misunderstand the meaning of the term. It is our opinion that if Florida and the West Indies were not separated by a sizable body of water, Smith and Kohler would not have distinguished such a category. All three of the taxa mentioned above appear to have invaded south Florida prior to the occupation of the area by modern humans. By way of comparison, one would not consider the indigo snake, *Drymarchon corais couperi,* to be introduced into the southeastern United States from Latin America even though its range is separated by a considerable distance from that of its nearest subspecific relative, *D. c. erebennus,* to the west. By such reasoning we consider the above-mentioned lizards to be native members of the south Florida herpetofauna. Schwartz (1968), however, mentioned the possibility that the population of the bark anole in south Florida designated as *Anolis d. floridanus* may have originally been introduced from the western coast of Andros Island. This contention is based on the characters of a single female lizard, but is not well supported. For the present, we consider that *A. d. floridanus* arrived in Florida prior to the appearance of modern man.

Duellman and Schwartz are the only authors who attempted to discuss the relative abundance of south Florida's amphibians and reptiles. They recognized six major habitat types, viz., xeric, mesic, alternohygric, hygric, halohygric, and edificarian-ruderal. They categorized the relative abundance of each species of amphibian and reptile in these habitat types as abundant, moderately abundant, apparently rare, and presence not established. Since that time, the importance of the edificarian-ruderal category has become markedly expanded, as natural habitats have increasingly succumbed to agricultural and urban development. Utilization of Duellman and Schwartz's system of categorization will not adequately describe the current situation, so we have devised a different system in order to discuss the changes that have occurred in the area's amphibian and reptile populations. This system includes the following:

1. Taxa having undergone population reduction as a result of urbanization and agriculturalization.
2. Taxa having apparently maintained stable populations in natural areas still available to them or having been able to maintain themselves in areas modified by humans.
3. Taxa of special consideration, i.e., those that do not easily fit into the above two categories. This group includes taxa whose populations are subject to differing pressures in different areas of south Florida.

In their analysis of the relative abundance of the south Florida herpetofauna, Duellman and Schwartz acknowledged several sources of error in their interpretations. We are operating with similar limitations. As with Duellman and Schwartz, our conclusions are based on observations made in connection with field work, as opposed to detailed studies of population dynamics. Population shifts due to cyclic changes are not apparent, and we have few data on how population changes in other groups of animals, especially predator and prey species, both native and introduced, may be affecting the amphibian and reptile populations. Finally, the herpetofauna of the Florida Keys remains relatively poorly known compared with that of mainland south Florida. Given these sources of error, our conclusions concerning the present-day relative abundance of the area's herpetofauna follow. This discussion is arranged according to the three categories delineated above.

Category 1—Taxa having undergone population reduction.—This group includes twenty-three species of amphibians and reptiles whose population size has decreased throughout the range of the animal in south Florida primarily as a result of increasing urban and agricultural development. We have further divided this category into three subcategories: species occurring in upland, wetland, and brackish areas. The following upland species are those occurring in pine flatwoods, hardwood hammocks, or sand scrub habitats:

Hyla femoralis
Hyla gratiosa
Rana areolata
Gopherus polyphemus
Ophisaurus attenuatus
Sceloporus woodi
Heterodon platyrhinos
Masticophis flagellum
Pituophis melanoleucus
Rhadinaea flavilata
Tantilla oolitica
Tantilla relicta
Crotalus adamanteus

Several species are more or less peripheral to the south Florida area (*Hyla femoralis, H. gratiosa, Rana areolata, Gopherus polyphemus, Ophisaurus attenuatus, Sceloporus woodi, Pituophis melanoleucus, Rhadinaea flavilata,* and *Tantilla relicta*) and probably were never prominent features of the south Florida herpetofauna. Nonetheless, they have declined in population size within the area. We assume such is the case with the pine woods snake (*R. flavilata*), but this species is known from only two south Florida specimens, both from Palm Beach County, one reported by Myers (1967) and a second recently collected (UF 52711). Eastern hognose snakes (*Heterodon platyrhinos*) and coachwhips (*Masticophis flagellum*) were more widespread in south Florida, occurring primarily in upland areas, but they have suffered the same fate as the above-mentioned peripheral species. The eastern diamondback rattlesnake (*Crotalus adamanteus*) has been included in this category inasmuch as its primary area of occurrence is in upland habitats (Duellman and Schwartz 1958) and it is in those areas that the species has undergone its most severe population decline. Limited adaptation to agricultural areas is possible in this species so long as sizable pine-woods refuges remain nearby. The rim rock crowned snake (*Tantilla oolitica*) is endemic to south Florida and, until recently, was known only from Dade County and Key Largo in the Florida Keys. Porras and Wilson (1979), however, demonstrated the occurrence of this snake in the middle Keys. The population of *T. oolitica* and the remainder of the above-listed upland species are severely threatened with extirpation in southern Florida because their primary habitats have been destroyed, and none appears able to adapt well to urban areas.

The following wetland species of amphibians and reptiles are those occurring in sawgrass prairies, cypress swamps and canals:

Pseudobranchus striatus	*Limnaoedus ocularis*
Siren lacertina	*Farancia abacura*
Notopthalmus viridescens	*Regina alleni*
Acris gryllus	*Seminatrix pygaea*

The populations of these species have all decreased, probably as a result of man's alteration of the natural water flow and other related factors (e.g., pesticides, slaughter by people, fires, and vehicular traffic). Of this group, the greater siren (*Siren lacertina*) and mud snake (*Farancia abacura*) seem to be the least adversely affected.

The southern chorus frog (*Pseudacris nigrita*) appears to occupy a subcategory distinct from the above two, because it inhabited the pineland-sawgrass prairie ecotone where it lived in limestone sinkholes. Today little of such habitat remains and the frog is extremely localized.

One species inhabits brackish coastal areas in mangrove forests. This is the American crocodile (*Crocodylus acutus*), whose population status is one of the most thoroughly documented as a result of the work of Ogden (1978), Wilcox (1979), and the continuing work of Paul Moler (pers. comm.) and the State of Florida Game and Fresh Water Fish Commission on the Key Largo population.

Category 2—Taxa with relatively stable populations in natural or man-modified areas.—This group includes thirty-one species of amphibians and reptiles whose populations have remained relatively stable as a result of their ability to maintain themselves in the natural areas still available to them or to adapt to areas modified by humans. It should be understood that it is difficult to subcategorize these species, inasmuch as any of the categories which we can develop are not mutually exclusive. What follows, however, is our attempt to do so.

The following group of species includes those that occur primarily in natural areas but also inhabit man-made bodies of water within these areas:

Rana grylio
Rana sphenocephala
Deirochelys reticularia
Kinosternon baurii
Kinosternon subrubrum
Sternotherus odoratus
Nerodia cyclopion
Nerodia fasciata
Thamnophis sauritus

All of the turtles, with the exception of *K. baurii*, appear never to have been abundant historically, but they still seem to be maintaining themselves in relatively stable populations. The striped mud turtle (*Kinosternon baurii*) is abundant in peninsular Florida and in the Lower Keys (Dunson 1981). The other species are all relatively common in the areas indicated.

Another group of species, indicated as follows, includes those that are widespread, occurring in both natural and urban-agricultural areas:

Amphiuma means
Gastrophryne carolinensis
Hyla cinerea
Hyla squirella
Chelydra serpentina
Pseudemys floridana
Pseudemys nelsoni
Trionyx ferox
Eumeces inexpectatus
Ophisaurus compressus
Ophisaurus ventralis
Coluber constrictor
Diadophis punctatus
Elaphe guttata
Elaphe obsoleta
Lampropeltis triangulum
Nerodia taxispilota
Opheodrys aestivus
Storeria dekayi
Thamnophis sirtalis

There is also a group that appears to adapt well to urban-agricultural areas so long as minimal living requirements are available. Included are the frogs and lizards, as well as six snakes: *Coluber constrictor, Diadophis punctatus, Elaphe guttata, Opheodrys aestivus, Storeria dekayi,* and *Thamnophis sirtalis.* The island glass lizard (*Ophisaurus* *compressus*) and rough green snake (*Opheodrys aestivus*), however, seem to exhibit a lesser degree of tolerance for development. The turtles are abundant in canal situations both in natural and urban-agricultural areas, with the exception of the snapping turtle (*Chelydra serpentina*), which is more common in canals outside of the latter areas. Another group of species, especially *Amphiuma means*, *Elaphe obsoleta*, *Lampropeltis triangulum*, and *Nerodia taxispilota*, have taken advantage of new habitats created by the establishment and naturalization of certain exotic plants. All three snakes have exploited the niche provided by the expanding forests of Australian pine, particularly in the Lake Okeechobee area. The two-toed amphiuma (*Amphiuma means*) is commonly found in mats of water hyacinths. Certain other species (*Hyla cinerea*, *H. squirella*, *Eumeces inexpectatus*, *Coluber constrictor*, *Diadophis punctatus*, and *Elaphe guttata*) are oftentimes found in these habitats, but do not appear to be so dependent on them.

A final group of two lizards, *Anolis distichus floridanus* and *Sphaerodactylus notatus*, occur almost solely within urban areas along the eastern coast of south Florida. *Anolis d. floridanus* is widespread throughout metropolitan Dade County in lushly landscaped areas or in remnant hardwood hammocks. *Sphaerodactylus notatus* occurs in leaf litter and underneath trash piles in and around hardwood hammocks and other areas as reported by Duellman and Schwartz.

Category 3—Taxa of special consideration.—This group includes sixteen species whose populational status does not allow them to fit easily into the above-discussed categories. Their populations are subject to differing pressures in disparate areas of their range in south Florida. As within the above category, the subcategories we have designated are not mutually exclusive. The first subdivision includes those species that remain abundant within relatively undisturbed areas of their range in south Florida, but whose populations have been severely reduced in urbanized areas. They are:

Bufo quercicus
Bufo terrestris
Scaphiopus holbrookii
Terrapene carolina
Cnemidophorus sexlineatus
Scincella lateralis
Micrurus fulvius

Another subcategory includes two snakes whose populations have been reduced in a portion of their ranges because of man's manipulation of water levels in the Everglades. These species are:

Agkistrodon piscivorus
Sistrurus miliarius

The last subcategory includes those species which have distinctive histories. They are:

Alligator mississippiensis	*Cemophora coccinea*
Malaclemys terrapin	*Drymarchon corais*
Anolis carolinensis	*Lampropeltis getulus*
Eumeces egregius	

Historically, the American alligator was abundant throughout south Florida. Poaching and drainage brought about a severe decline in the animal's populations, but after the alligator was afforded protection, it made a phenomenal comeback. The state of Florida now spends about a quarter of a million dollars each year in a program to remove alligators that have become a "nuisance" (Endangered Species Technical Bulletin 1978).

Three subspecies of the diamondback terrapin (*Malaclemys terrapin*) occur in the south Florida area. *Malaclemys t. tequesta* has never been known to be abundant in Atlantic coastal south Florida and was known to Duellman and Schwartz from a single specimen from Miami Beach. In recent years, however, two specimens have been sighted in Biscayne Bay (C. R. Warren, pers. comm.) and a third turtle was collected near Government Cut in Miami Beach (B. Mealey, pers. comm.). The mangrove diamondback terrapin (*M. t. rhizophorarum*) from the Florida Keys is known only from a few museum specimens, but it is more abundant than once thought, judged by the number of shells found in abandoned eagle nests (Rudloe 1979). We are also aware of a few recent sightings. *Malaclemys t. macrospilota*, on the other hand, is abundant along Gulf coastal south Florida.

The green anole (*Anolis carolinensis*) was noted by Duellman and Schwartz (1958) to be "abundant throughout the keys and most of southern Florida with the exception of the Everglades where they occur sporadically. The optimum habitat appears to be in mesophytic hammocks; this type of habitat often is artificially represented in gardens and shrubbery around houses, and in such places anoles are abundant. Many individuals have been found at night sleeping on reeds and grasses." Since that time, *A. carolinensis* has undergone a downward population shift in urban areas primarily due to the accelerated disappearance of urban vegetation resulting from the increased density of buildings. The once abundant mesophytic hammocks and residential vegetation have become so reduced as to limit their occurrence. In other human-modified areas, however, the green anole has become more abundant. This is especially true in sugar cane fields, orange groves, and Australian pine groves.

Two subspecies of the mole skink (*Eumeces egregius*) occur in south Florida. *Eumeces e. onocrepis* ranges throughout much of peninsular Florida, but is extremely rare in south Florida. Recently a specimen was collected in a sand strip in a yard near S.W. 59th Avenue and 102nd Street in Miami (UF 50063). To our knowledge, this was the first specimen collected in Dade County in over twenty years. We are also aware of another specimen collected and released on the west coast near Estero, Lee County (S. Bazemore, pers. comm.). The other subspecies, *E. e. egregius*, is confined to the Florida Keys. Although this lizard is uncommonly reported, it is probably more abundant than indicated in the literature because it is difficult to locate and capture due to its arenicolous habits. We have encountered this skink on Grassy Key and Big Coppit Key, and have reports of a population on Bahia Honda Key.

The scarlet snake (*Cemophora coccinea*) apparently was never abundant in south Florida. Duellman and Schwartz (1958) reported this snake as occurring "in pine woods, rosemary scrub, and in mesophytic hammocks." They further noted that "it does not inhabit the Everglades, nor is it found on the keys." Since that time one of us (LP) has seen a number of specimens, most of which have come from the vicinity of Pinecrest (a pine island in the Everglades). In recent years, several specimens have been found in sawgrass prairies that were formerly under water but are now dry due to drainage. The main area of this snake in south Florida, the Atlantic coastal ridge, however, no longer supports it.

The indigo snake (*Drymarchon corais*) has been able to adapt moderately well to disturbed areas, particularly citrus groves where they live in armadillo burrows and in areas supporting Australian pines (particularly those that lie near the seashore in southeastern Florida where the snake lives in crabholes). This snake has become increasingly restricted in range because of development. Southeastern Dade County (east of Homestead and Florida City), which area supports the largest population of the species in south Florida, is slated for rapid urban development. Unless measures are quickly taken at least to maintain agricultural zoning in the area the indigo snake is very likely to disappear from southeastern Florida.

The situation with the common kingsnake (*Lampropeltis getulus*) is unusual in that the animal has undergone a marked population increase in one portion of its range and a rapid decline in another. This kingsnake is remarkably abundant in the sugar cane plantations south of Lake Okeechobee. The plantations were historically under water, but have now been drained. The embankments alongside drainage canals provide refuges and the cane fields attract large rodent populations which provide an ample food supply. On the other hand, the population of this snake along the Tamiami Trail has declined in number in a fashion similar to those wetland species grouped under category 1 of this section. The population occurring on the extreme southeast Florida mainland, especially in the area south of Florida City, which is distinctive in coloration and diet (primarily turtle eggs), is also undergoing a serious population decline. *Lampropeltis getulus* and also three other snakes, *Nerodia fasciata*, *Crotalus adamanteus*, and *Sistrurus miliarius*, are occasionally found emaciated and lethargic. Pesticide poisoning may be responsible, inasmuch as specimens sent for pathological analysis turned up no evidence of bacterial or parasitic infestation (J. Campbell, pers. comm.). This situation is sorely in need of study.

The Introduced Herpetofauna

Summary information on introduced herpetofauna has appeared at intervals over the last forty years (Carr 1940; Carr and Goin 1955; Duellman and Schwartz 1958; King and Krakauer 1966; Smith and Kohler 1978). A summarization of the numbers of species of various herpetological groups reported by these authors and by us is indicated in Table 3. The data in this table are based on the same definitions discussed in the section on the native herpetofauna.

The data in Table 3 illustrate that no significant change in the size of the introduced herpetofauna as a whole occurred between 1940 and 1958, but that between 1958 and the present the number increased more than three-fold. The increase was primarily due to the influx of exotic lizard species.

South Florida's introduced and established (=breeding) herpetofauna of 25 species is, of course, the largest of any state in the United States (Table 4). It is only approached by that of Hawaii with 18 species (McKeown 1978). California (Bury and Lukenbach 1976) and Texas (Thomas 1974; Conant 1977), with 9 and 6 introduced species, respectively, fall far behind.

Bader (1976) listed a number of turtles as established and breeding on the Crandon Park Zoo grounds at Key Biscayne. A number of exotic turtles have been released into canals and lakes within the zoo grounds, but they exist essentially in a controlled situation within the park which is located on an island. Our observations and those of former members of the Crandon Park Zoo staff suggest that most of these species are no longer breeding. These species, therefore, are excluded from the following discussion. What follows in this section is an update of the information available on south Florida's introduced herpetofauna. Each species is discussed in a separate account.

Bufo marinus.—Neill (1957) first reported the giant toad (Fig. 8) as introduced into south Florida from an unspecified locality. Duellman and Schwartz (1958) and Riemer (1958) indicated that the toad may have been introduced into sugar cane fields near Pennsuco (now located at the junction of Okeechobee Road and the Homestead extension of the Florida Turnpike), but that more likely the present populations came from specimens either accidentally or purposely released by animal dealers in the Miami area. King and Krakauer (1966) said, however, that "the present population is not the result of an introduction near Pennsuco prior to 1958 . . . but results from the accidental release of approximately 100 specimens by an importer formerly located at Miami International Airport, whence the species spread." They also pointed out that "other animal dealers

TABLE 3. Comparison of established breeding species reported by several summary papers on the introduced herpetofauna of south Florida (A = extant introduced species listed by author(s); B = species still established).

Group	Carr (1940)		Carr and Goin (1958)		Duellman and Schwartz (1958)		King and Krakauer (1966)		Smith and Kohler (1978)		Present Paper
	A	B	A	B	A	B	A	B	A	B	
Frogs	2	2	2	2	3	3	3	3	4	3	3
Turtles	0	—	0	—	0	—	0	—	0	—	1
Crocodilians	0	—	0	—	0	—	0	—	0	—	1
Lizards	5	5	6	5	4	4	10	10	12	11	19
Snakes	0	—	0	—	0	—	0	—	0	—	1
Totals	7	7	8	7	7	7	13	13	16	14	25

TABLE 4. Comparison of the introduced herpetofaunas in four areas in the United States (? = uncertain breeding status).

Species	South Florida	South Texas	California	Hawaii
1. *Ambystoma tigrinum*			x	
2. *Bufo marinus*	x			x
3. *Dendrobates auratus*				x
4. *Rana catesbeiana*			x	x
5. *Rana pipiens*			x	
6. *Rana rugosa*				x
7. *Xenopus laevis*			x	
8. *Eleutherodactylus planirostris*	x			
9. *Osteopilus septentrionalis*	x			
10. *Ameiva ameiva*	x			
11. *Anolis carolinensis*		x	x	
12. *Anolis cristatellus*	x			
13. *Anolis cybotes*	x			
14. *Anolis distichus*	x			
15. *Anolis equestris*	x			
16. *Anolis garmani*	x			
17. *Anolis porcatus*				x
18. *Anolis sagrai*	x			
19. *Basiliscus vittatus*	x			
20. *Chamaeleo jacksonii*				x
21. *Cnemidophorus lemniscatus*	x			
22. *Hyla cinerea*		x		
23. *Ctenosaura pectinata*	x	x		
24. *Ctenosaura hemilopha*			?	
25. *Cryptoblepharus boutonii*				x
26. *Gekko gecko*	x			
27. *Gehyra mutilata*				x
28. *Gonatodes albogularis*	x			
29. *Hemidactylus frenatus*				x
30. *Hemidactylus garnotii*	x			x
31. *Hemidactylus turcicus*	x	x		
32. *Hemiphyllodactylus typus*				x
33. *Iguana iguana*	x			x
34. *Emoia cyanura*				x
35. *Leiocephalus carinatus*	x			
36. *Leiocephalus schreibersi*	x			
37. *Lipinia noctua*				x
38. *Leiolopisma metallicum*				x
39. *Lepidodactylus lugubris*				x
40. *Sphaerodactylus argus*	x			
41. *Sphaerodactylus elegans*	x			
42. *Chelydra serpentina*			x	
43. *Pseudemys concinna*		?		
44. *Pseudemys scripta*	x		?	
45. *Trionyx spiniferus*			x	
46. *Trionyx sinensis*				x
47. *Caiman crocodylus*	x			
48. *Ramphotyphlops bramina*	x			x
49. *Nerodia fasciata*		x		
Totals	25	6	9	18

FIGURE 8. Giant Toad (*Bufo marinus*). (LP)

deliberately released the species in 1963 at Pembroke Park, Broward County, and in 1964 at Kendall, Dade County." Subsequent authors (Bartlett 1967, 1980; Krakauer 1968, 1970; Gore 1976; Austin *in* Morris 1977) have essentially reiterated the information provided by King and Krakauer (1966). Krakauer (1968) first reported the giant toad from Palm Beach County. The toad was recorded as established on Stock Island, near Key West, by Krakauer (1970), and we know it to be breeding on Key West as well. *Bufo marinus* is common in many urban and agricultural areas in southeastern Florida, and is present on the fringes of the Everglades (e.g., the vicinity of Chekika State Recreation Area, west of Florida City, and near the junction of the Tamiami Trail and U.S. 27).

Eleutherodactylus coqui.—This frog was first reported in south Florida by Austin and Schwartz (1975) on the basis of a small population at Fairchild Tropical Garden. Those authors thought that perhaps a breeding population had been established. The frog was last heard in 1976, however, and it is probable that the freezing weather during January 1977 extirpated the population, inasmuch as males have not been heard calling since (pers. comm., Fairchild Tropical Garden Staff).

Eleutherodactylus planirostris.—Cope (1875) first recorded the greenhouse frog (Fig. 9) from "south Florida" and later (1889) from Key West. Barbour (1910) recorded the species from Eau Gallie, Brevard County. Since that time, the species has been found virtually throughout peninsular Florida, including the Florida Keys. Carr (1940) reported it as "the commonest frog on Key West." He also

FIGURE 9. Greenhouse Frog (*Eleutherodactylus planirostris*). (LP)

noted it to occur in Florida City and Homestead. It is locally common in various portions of southeastern and southwestern Florida and is usually encountered under trash. An excellent summary of the biology of this species was published by Goin (1947). Schwartz (1974) recently summarized the known distribution of *E. planirostris* in Florida.

Osteopilus septentrionalis.—The Cuban treefrog (Fig. 10) was first reported from Key West by Barbour (1931b). Since that time it appears to have dispersed northward, having been reported on Upper Matacumbe Key by Trapido (1947), Key Largo by Allen and Neill (1953), Miami by Schwartz (1952), Dania by King (1960), the Broward-Palm Beach County line by Lee (1969), Palm Beach County by Austin (1975), and Saint Lucie and Indian River counties by Myers (1977). On the west coast it has been reported from Naples by Duellman and Crombie (1970) and we know it to occur in Fort Myers, Sanibel Island, and Fort Myers Beach. Information on this species was summarized by Duellman and Crombie (1970).

Ameiva ameiva.—The South American ground lizard (Fig. 11) was originally reported from south Florida by Neill (1957) from an unstated locality. Duellman and Schwartz (1958) stated that this lizard was first known to be established in Dade County in 1954 in overgrown vacant lots near the junction of N.W. 34th Avenue and 79th Street in Miami. King and Krakauer (1966) reported the species (as *A. a. petersi*) as occurring in an area of 25 city blocks from N.W. 79th Street south to 76th Street and from 36th Avenue west to Le Jeune Road. They also reported that *A. a. ameiva* had been released

FIGURE 10. Cuban Treefrog (*Osteopilus septentrionalis*). (JB)

near S.W. 78th Avenue and 125th Street (in what used to be called Suniland) and near W. 27th Street and E. 7th (=W. 7th) Avenue in Hialeah. The former population is still extant, but the latter is not. We herein report the existence of a well-established and large population of this lizard on the Crandon Park Zoo Grounds in Key Biscayne, and a small, but well established population, in the vicinity of N.W. 72nd Avenue and 46th Street. The latter has been in existence since at least 1975, but its fate appears to be in doubt since the area is being bulldozed for construction of warehouses. Conant (1975) stated (on the basis of information from A. Echternacht) that the present population in Miami "may have been derived from the interbreeding of two tropical American races of this species." The races in question are apparently *A. a. ameiva* and *A. a. petersi*. The subspecific identity of the lizards is still in question (A. Echternacht, pers. comm.). However, it is clear that the adult males of the Suniland population are predominantly green, whereas those of all other populations in Dade County are predominantly blue and larger in size. All of the existing populations are in disparate areas of the city, unconnected to one another, and all, except the one on Key Biscayne, appear to be on the decline. Thus, we regard Conant's (1975) statement as questionable. We also have an unconfirmed report of a sighting of an *A. ameiva* in a vacant area north of the Seaboard Industrial Park and the north campus of Miami-Dade Community College, which is about 45 city blocks north of the N.W. 34th Avenue and 79th Street locality. Dispersal along the Seaboard Air Line right of way is conceivably possible.

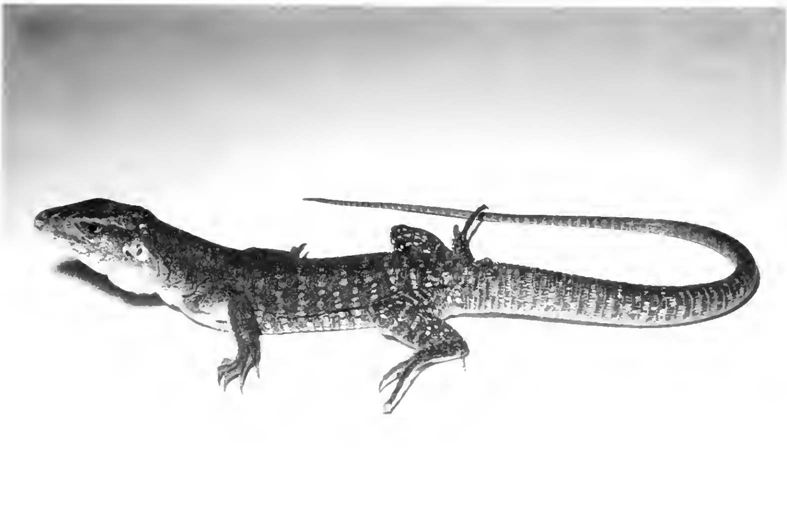

FIGURE 11. South American Ground Lizard (*Ameiva ameiva*). (IHC)

Anolis cristatellus.—This Puerto Rican lizard (Fig. 12) was first reported from "Biscayne Key" (=Key Biscayne), Dade County, by Schwartz and Thomas (1975). Brach (1977) provided information on its distribution and population density on Key Biscayne, reporting it to occupy a four block area in the vicinity of West Enid Drive on the southern portion of the key. The population is increasing slightly in the occupied area, and a secondary introduction from it is now present and flourishing on the Crandon Park Zoo grounds, also situated on Key Biscayne. In 1976 we became aware of a new locality for this lizard in the vicinity of S.W. 97th Street and 57th Avenue (Red Road). This population may have resulted from a separate introduction (not from the Key Biscayne populations), because adult males have a brighter, more orange dewlap. A secondary introduction is known by us to have been made a few blocks to the west.

Anolis cybotes.—This Haitian lizard (Fig. 13) was first reported in south Florida by Ober (1973) on the basis of a self-introduction at the author's home in northeastern Dade County. Although Ober (1973) reported a high probability of a spread of this anole from the original site of introduction via trash removal, we are unaware of any secondary introductions. *Anolis cybotes* is still abundant at the original site of introduction, but it appears to have spread only into the immediate vicinity.

Anolis distichus.—Three subspecies of this lizard have been reported from the Florida mainland (Smith and McCauley 1948; King and Krakauer 1966; Schwartz 1968). These are *A. d. floridanus*,

FIGURE 12. Crested Anole (*Anolis cristatellus*). (LP)

described by Smith and McCauley (1948) from Brickell Park in downtown Miami, Dade County, *A. d. dominicensis*, and *A. d. ignigularis*, the latter two reported by King and Krakauer (1966).

We consider *A. d. floridanus* to be a member of the native component of the herpetofauna. Historically, Brickell Hammock, "the most extensive tropical hammock in the state" (Barbour 1944) and the type locality of this anole was bounded by Biscayne Bay on the east and expanses of pine flatlands and the Miami River elsewhere. It is entirely possible that *A. d. floridanus* was limited in distribution to Brickell Hammock and other mesophytic hammocks along the Atlantic coastal ridge and that subsequent development, and the alteration of the natural vegetation, opened up a network of avenues for its dispersal. *Anolis d. floridanus* does not adapt to living in pine flatwoods, but it has established itself in well-vegetated areas of the city where it exhibits a preference for large, smooth-barked trees (e.g., various species of *Ficus* and *Schefflera*). It also occurs spottily in southern Broward County.

Anolis d. dominicensis (Fig. 14) was first reported by King and Krakauer (1966) as established and breeding in a small colony "along the Tamiami Canal near 32 Avenue and 24 Street Road N.W." Although that area has undergone considerable change since 1966, these lizards are still abundant along the edge of the waterway, especially in the bordering Australian pines. King and Krakauer (1966) stated that *A. d. dominicensis* "was most probably accidentally introduced on a freight boat that trades between the Miami

FIGURE 13. Large-headed Anole (*Anolis cybotes*). (LP)

River and Hispaniola." The population of *A. d. ignigularis* reported by King and Krakauer (1966) as released is no longer extant.

Anolis equestris.—The knight anole (Fig. 15) from Cuba was first reported in south Florida by Neill (1957) from an unspecified locality. King and Krakauer (1966) discussed the origin of the south Florida populations, indicating that specimens were released on the grounds of the old University of Miami campus by a biology student. They further stated that a breeding population was at that time established in a twenty city block area in Coral Gables, Dade County, and that secondary introductions occurred in various parts of the county. Since that time, *A. equestris* has become more widespread in Dade County (including Elliott Key and Virginia Key) and we have unconfirmed reports of its occurrence in Ft. Lauderdale, Broward County. *Anolis equestris* is usually found in areas that support

FIGURE 14. Green Bark Anole (*Anolis distichus dominicensis*). (LP)

a relatively luxuriant growth of large trees, especially exotic fruit trees, and ornamental trees such as the black olive. Perhaps, one reason for this lizard's success in urban areas of Dade County is the large number of food items available to it. Colette (1961), Ruibal (1964), Brach (1976) and Dalrymple (1980) have reported *A. equestris* as feeding on the following: palm and *Ficus* fruits, leaves, spiders, leafhoppers, cicadas, cockroaches, beetles, treefrogs, smaller anoles, young birds, and baby rats and mice. Brach (1976) stated that he was skeptical that *A. equestris* fed on mangos, as alleged by many Cubans. However, we have observed *A. equestris* to feed on ripe mangos. In addition to the reported food items we have also seen these anoles feeding on azalea flowers, tree sap, caterpillars, and large ants. *Anolis equestris* is most abundantly visible during the hottest days of the year.

Another factor which may contribute to the success of *A. equestris* in south Florida is its extended longevity as compared to most other anoline species. Puckette and Smith (1963) reported an *A. equestris* to have lived in captivity for six years and speculated it may have been at least eight years old at death. Lynch and Smith (1964) in examining the possibility of oligophydonty in a senile *A. equestris* stated that "rarely do these lizards live longer than two years in captivity and their age in nature probably rarely exceeds 5 years." We are aware, however, of two *A. equestris* whose captive longevity far exceeds that reported by Puckette and Smith (1963). John Boursot (pers. comm.) kindly informed us that both specimens were obtained (from the junior author) as adults on 5 November

FIGURE 15. Knight Anole (*Anolis equestris*). (LP)

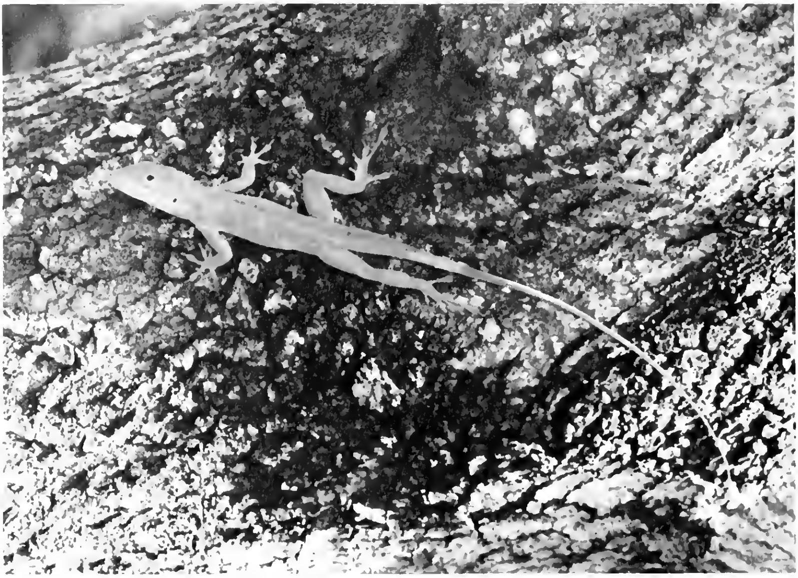

FIGURE 16. Jamaican Giant Anole (*Anolis garmani*). (LP)

1969. One specimen died accidentally on 22 March 1980; the other died an apparent natural death on 6 August 1981.

Anolis garmani.—The presence of this Jamaican lizard (Fig. 16) in south Florida was brought to our attention in 1975. In September of 1976 a series of one adult and four juveniles was collected in the vicinity of S.W. 63rd Court and 69th Street in South Miami, indicating that the population was breeding and established at least by that time. Local residents informed us that they had been aware of the lizard "for a number of years," but we were unable to track down the source of the introduction. At this time the population appears to be restricted to a few square blocks in the immediate vicinity of the above-cited corner in a well-vegetated pocket, and to have a seasonal activity peak during warm winter days. We originally intended to report the presence of this anole in south Florida in this paper, but it was done on the basis of our specimens in a popularized pamphlet by Roberts (1977).

Anolis sagrai.[2]—The brown anole (Fig. 17) was first reported from the "Florida Keys" by Garman (1887). The population from Key West was described as a new subspecies (*A. s. stejnegeri*) by Barbour (1931a). Goin (1947) reported it from Tampa, and Oliver (1950) from Lake Worth (city) and St. Petersburg. Bell (1953) noted

[2] We follow Smith and Smith (1976) in the use of the spelling of *sagrai* over *sagrei*.

FIGURE 17. Brown Anole (*Anolis sagrai*). (LP)

its occurrence in Miami and King (1960) in Palm Beach. In addition to the localities mentioned above, Ruibal (1964) listed the species as occurring in Coral Gables, Fort Myers, and on Cudjoe Key, and also synonymized *A. s. stejnegeri* with *A. s. sagrai.*

Since the above papers were written *Anolis sagrai* has become remarkably abundant and widespread in southeastern Florida and now is *the* most common reptile in urban areas. The spread was rapid, inasmuch as King (1960) pointed out that every population known at that time, with the exception of the one from Lake Worth, occurred in a seaport. In recent years the species has been reported from numerous localities outside of south Florida and away from the coast (Corwin, Linzey, and Linzey 1977; Meylan 1977a; Myers 1978a, 1981; Funk and Moll 1979; Wygoda and Bain 1980; Godley, Lohrer, Layne, and Rossi 1981).

Oliver (1950) reported *A. s. ordinatus* as occurring in Lake Worth. King and Krakauer (1966) reported a small colony in South Miami and Conant (1975) one at Chokoloskee Island, Collier County. Specimens from the Lake Worth locality collected in May of 1979 are either *A. s. sagrai* or show evidence of intergradation with *A. s. ordinatus.*

Anolis sagrai is highly successful because of its broad adaptability in edificarian areas. It, quite simply, occurs almost anywhere. For example, Albert Schwartz (pers. comm.) has seen males displaying on and living in the base of a concrete light pole in the asphalt parking lot at the North Campus of Miami-Dade Community Col-

FIGURE 18. Brown Basilisk (*Basiliscus vittatus*). (LP)

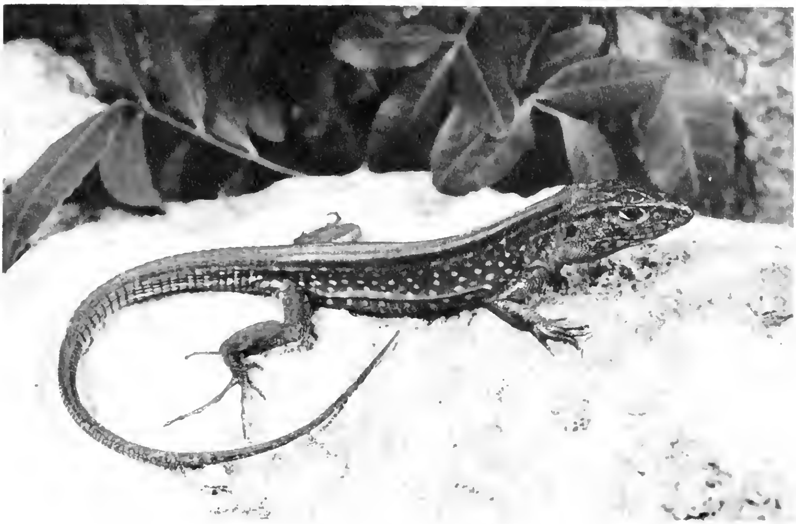

FIGURE 19. Rainbow Lizard (*Cnemidophorus lemniscatus*). (LP)

lege and one of us (LP) has seen individuals copulating at 0100 h in the middle of a gasoline station parking lot devoid of vegetation.

Basiliscus vittatus.—We first noted the establishment of a small colony of the brown basilisk (Fig. 18) on a sparsely-vegetated canal near the northwest corner of the Miami International Airport in 1976. Additional specimens of *B. vittatus* escaped from an animal dealer compound located at N.W. 70th Avenue and 70th Street. In 1979 juveniles were seen in both populations. In 1981 the latter locality was demolished but individuals were subsequently seen on a nearby canal bank. The merging of these populations is likely since the colonies are close to one another. We are also aware of a well-established colony along a canal on N.W. 70th Street between Sterling and Griffin Road in Davie, Broward County. Because of differences in coloration, we suspect that these populations are of separate origin.

Cnemodophorus lemniscatus.—King and Krakauer (1966) originally reported this lizard (as *C. picturatus*) as having been released in the vicinity of W. 27th Street and E. 7th Avenue (=W. 7th Avenue) in Hialeah, but it has not been seen again and is no longer extant there. Bartlett (1967) recorded this species as *C. picturata* (sic) as being found "over much of the area [Dade County] but especially prevalent in vacant lots on 79th Street." As pointed out by Smith and Kohler (1978), there is no such species as *Cnemidophorus picturatus*, but they erroneously suggested that the animal released might have been *Hemidactylus picturatus* from South Africa. In actuality the animal is *C. lemniscatus* (Fig. 19), and it is established and

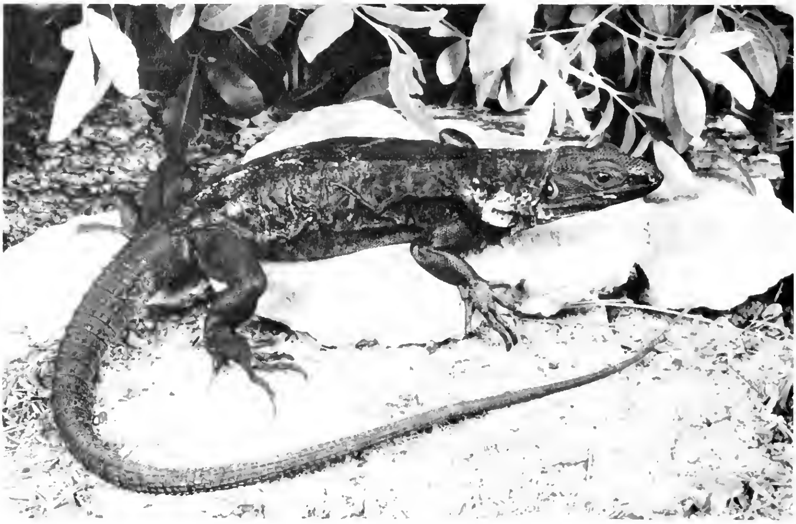

FIGURE 20. Mexican Spiny-tailed Iguana (*Ctenosaura pectinata*). (LP)

breeding in a small area adjacent to the Florida East Coast Railway at N.W. 37th Avenue (Douglas Road) and 75th Street. The vicinity is occupied by industrial buildings, but the lizards occur in the weeds growing along the railroad right-of-way and escape into holes underneath the buildings just north of the railroad.

Ctenosaura pectinata.—The spiny-tailed iguana (Fig. 20) has been known to be established in the Miami area for many years (perhaps since the early 1960's), because specimens were brought into local pet stores. It was not until 1978, however, that the lizard was first reported in the literature, in a popularized article appearing in Florida Wildlife (Eggert 1978), where it was erroneously identified as *Ctenosaura similis*. The colony is located along Old Cutler Road between Richmond Drive (S.W. 168th Street) and Eureka Drive (S.W. 184th Street) in an area supporting remnant hardwood hammock and pine flatwoods adjacent to Biscayne Bay. Much of this area is occupied by homes with extensive yards, fronted, in many cases, by oolite rock walls. Mangos and other tropical fruit trees have been planted in the area, and in scarified areas Australian pines have taken over. A large artificial lagoon lies between Old Cutler Road and the bay. The ground is sandy, a decided advantage for the lizards, enabling them to dig burrows in which to lay their eggs and to use as retreats. In one area of abandoned dwellings, numerous boards have been piled up which afford the lizards shelter. We have been observing this population since 1972. Recently the area inhabited by the nucleus of the population has undergone further modification. The abandoned houses have been torn down, some

FIGURE 21. Tokay Gecko (*Gekko gecko*). (LP)

board piles have been cleaned up, and some large piles of tree trunks and limbs in which the lizards lived have been burned. The area is now fenced and seems slated for a future housing development. We believe this area to be the primary nesting ground for the lizards; the frequency of young seen during the past few seasons has decreased. At any rate, the survival of *C. pectinata* appears reasonably assured, even if in a reduced fashion, because it also inhabits the rock walls along the fronts of certain properties on the bay side of Old Cutler Road, and it also occurs on roofs and foundations of houses, and in trash piles and tree hollows. Eggert (1978) reported finding 13 *Ctenosaura* eggs which had been buried in sand. In early June 1975, one of us (LP) dug several gravid iguanas out of their burrows and they later laid eggs in captivity. *Ctenosaura pectinata* appears to feed on leaves of various types of vegetation, as determined by examination of feces. In addition we have observed them to eat mamey fruit.

Gekko gecko.—The tokay gecko (Fig. 21) has been introduced in disparate localities in Dade and Broward counties. The species is usually liberated in the confines of someone's home for control of cockroaches. Although released at a number of localities, we are unaware of any sizable population. These geckos appear to remain close to their site of introduction. If a group of individuals occurs within a building, territories are established and the geckos will usually move outside their territorial limits only to mate.

Gonatodes albogularis.—The yellow-headed gecko (Fig. 22) was first reported as introduced in Key West by Carr (1939). The gecko

FIGURE 22. Yellow-headed Gecko (*Gonatodes albogularis*). (IHC)

was reported as being abundant on the western side of Key West. In 1971 a series of specimens was collected by E. R. Robinett, but recent efforts have failed to turn up any. We have been unable to find specimens at the locality near Day Avenue and Matilda Street in Coconut Grove mentioned by King and Krakauer (1966).

Hemidactylus garnotii.—This gecko (Fig. 23) was reported by King and Krakauer (1966) from two separate localities in the Miami area. They postulated that the introduction may have resulted from specimens collected during the International Indian Ocean Expedition (1960–1963) and later released at the houses of two University of Miami personnel located in southwest Miami and Coconut Grove. Prior to 1960, however, the lizard was known to one of us (LP) to be established in several localities in Hialeah. Kluge and Eckardt (1969) reported the species from the Everglades National Park and McCoy (1972) from Sanibel Island in Lee County. This gecko has now become widespread throughout Dade County and we know it to occur along the Tamiami Trail at least as far west as Monroe Station in Collier County. The northernmost locality on the east coast is Floridana Beach, Brevard County, reported by Myers (1979). Mitchell and Hadley (1980) listed it from Naples, Collier County, and we also know it to occur in Fort Myers, Lee County, and in the Florida Keys on Upper Matacumbe and Grassy keys. Steiner and McLamb (1982) recently reported a specimen from the Dry Tortugas, Monroe County. The Indo-Pacific gecko is expanding its range in south Florida more rapidly than its congener, presumably because it reproduces parthenogenetically.

FIGURE 23. Indo-Pacific Gecko (*Hemidactylus garnotii*). (LP)

Hemidactylus turcicus.—Fowler (1915) first reported the Mediterranean gecko (Fig. 24) from Key West. The distribution of *H. turcicus* in south Florida was summarized by King and Krakauer (1966) and McCoy (1970). Since that time other localities in Florida outside of our study area have been reported by McCoy (1971).

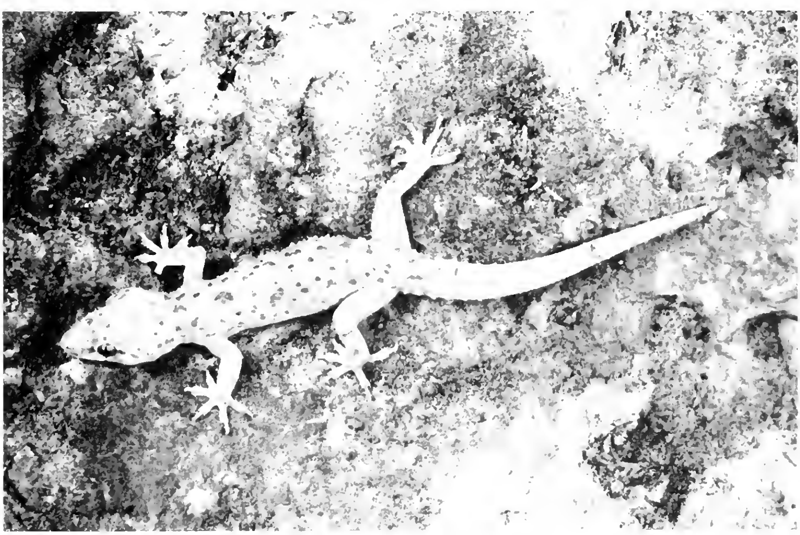

FIGURE 24. Mediterranean Gecko (*Hemidactylus turcicus*). (LP)

FIGURE 25. Green Iguana (*Iguana iguana*). (LP)

Meylan (1977b), and Myers (1978b). We also have a specimen from Broward County. This gecko is almost strictly edificarian, usually occurring on the sides of buildings.

Iguana iguana.—The green iguana (Fig. 25) was reported by King and Krakauer (1966) to be established but non-breeding in four separate localities in the Miami area. At present, we are aware of three breeding populations. One is along a series of canals near the northwest corner of the Miami International Airport and a second is on Key Biscayne on the Crandon Park Zoo grounds. The airport population is a small one occurring along a sparsely-vegetated series of canal banks and presumably resulted from the release of specimens from animal dealer compounds located in the area. The Key Biscayne population is larger and undoubtedly originated from zoo escapees. In addition, there is a third and well-established population on the grounds of the Miami Seaquarium on Virginia Key. Bartlett (1980) mentioned the existence of a colony in Collier County.

Leiocephalus carinatus.—Three subspecies of the curly-tailed lizard (Fig. 26) have been recorded from south Florida, but only one appears to remain established. *Leiocephalus c. virescens* was reported by Barbour (1936) from Miami, but Duellman and Schwartz (1958) stated that it was no longer established.

King and Krakauer (1966) indicated that *L. c. coryi* was believed to occur on the grounds of the Crandon Park Zoo on Key Biscayne, but they were unable to collect any specimens. We have likewise been unable to find any specimens.

FIGURE 26. Curly-tailed Lizard (*Leiocephalus carinatus*). (LP)

Leiocephalus carinatus was reported from Palm Beach (as *L. c. virescens*) by Duellman and Schwartz (1958). King (1960) later studied the Palm Beach population and determined it to consist of *L. c. armouri* and to occur on both the island of Palm Beach and the adjacent mainland. Today the lizard is abundant at both localities and has also been sighted at Boynton Beach. King and Krakauer (1966) and Schwartz and Thomas (1975) further reported *L. c. armouri* to be established on the grounds of the Miami Seaquarium on Virginia Key and also on Key Biscayne (Crandon Park Zoo). Apparently, none still remain at the zoo, but the population on Virginia Key is well-established on the Seaquarium grounds and environs. We are also aware of a new population on the premises of the National Oceanographic and Atmospheric Administration at the Port of Miami.

Leiocephalus schreibersi.—This Hispaniolan curly-tailed lizard (Fig. 27) has been established in Dade County at least since 1978 at N.W. 70th Avenue and 70th Street. The introduction of *L. schreibersi* resulted from escapees imported by an animal dealer from the north coast of Haiti. We observed young specimens in 1979. The area was bulldozed in late 1981 and we have seen no specimens there since. A secondary introduction from this population, however, is present in the vicinity of N.W. 67th Avenue and Kilmarnock Drive in Miami Lakes and was established shortly after the parent population.

Sphaerodactylus argus.—Savage (1954) first reported the ocellated gecko (Fig. 28) from Key West. Duellman and Schwartz (1958)

FIGURE 27. Red-sided Curly-tailed Lizard (*Leiocephalus schreibersi*). (LP)

stated that the population was no longer extant, but King and Krakauer (1966) indicated that the lizard had been seen near the aquarium at Mallory Square on the western end of the island. We have a specimen collected on Stock Island in 1977, and Love (1978) recently reported collecting a specimen in a vacant lot in Key West.

Sphaerodactylus elegans.—Stejneger (1922) was the first to record the ashy gecko (Fig. 29) from Key West. Duellman and Schwartz (1958) confirmed its occurrence on Key West and also reported it on Boca Chica Key to the north. One of us (LP) has found the lizard

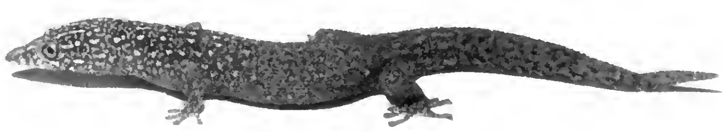

FIGURE 28. Ocellated Gecko (*Sphaerodactylus argus*). (IHC)

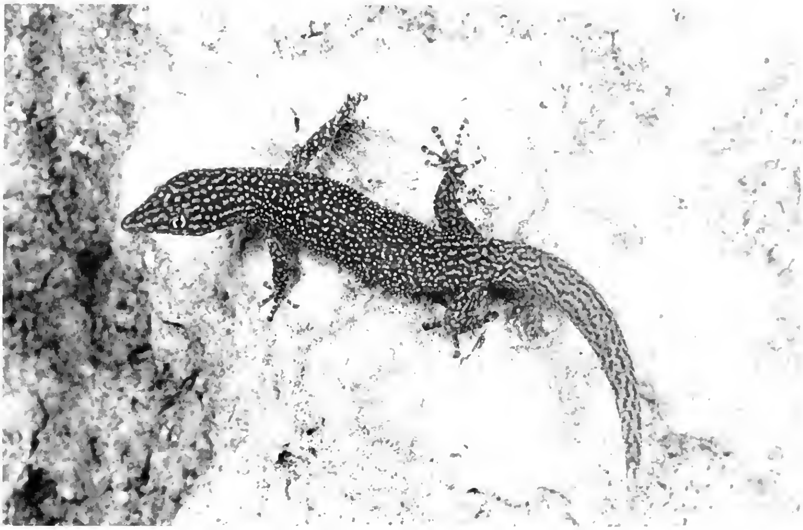

FIGURE 29. Ashy Gecko (*Sphaerodactylus elegans*). (JB)

on Big Coppit Key, the key directly north of Boca Chica Key. Graham and Schwartz (1978) pointed out that *elegans* is the correct specific name for this gecko, which was formerly called *S. cinereus*.

Caiman crocodylus.—King and Krakauer (1966) reported that specimens of the brown caiman (Fig. 30) were occasionally released

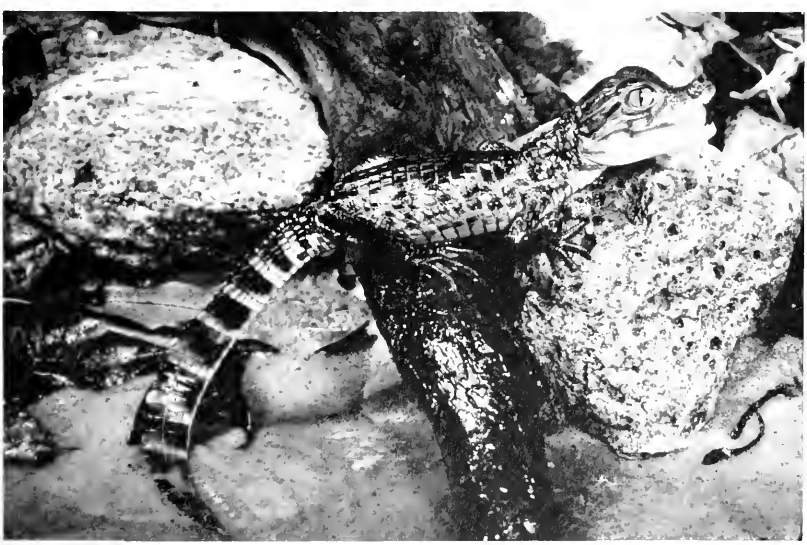

FIGURE 30. Brown Caiman (*Caiman crocodylus*). (JB)

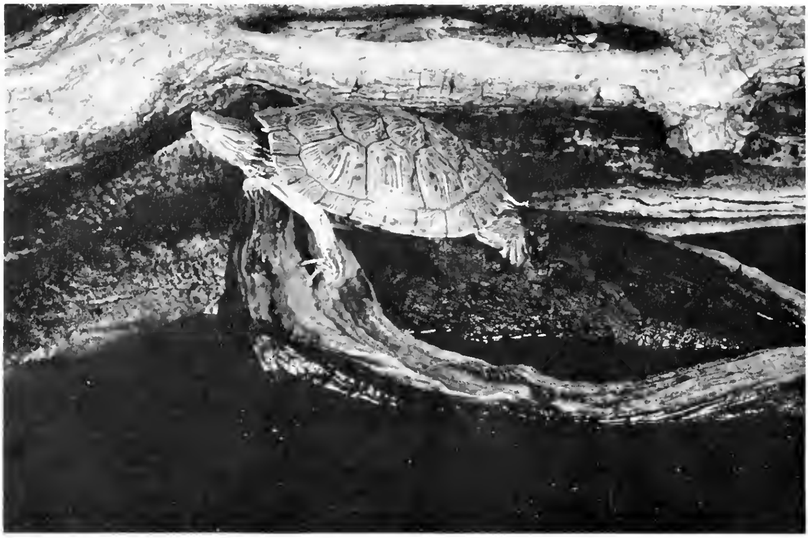

FIGURE 31. Red-eared Slider (*Pseudemys scripta elegans*). (JB)

in south Florida and became feral, but were not known to be breeding. One of us (LP) observed a number of caimans of various sizes in the late 1950's in a section of a canal which extended from Maule Lake to N.W. 27th Avenue. Ellis (1980) had information of caimans in canals in Miami as early as 1960. In 1968 specimens from a canal in North Miami in the vicinity of N.W. 22nd Avenue and 197th Street were brought to the animal trade by a local collector. Animals up to six feet in length were captured and the collector reported having seen nests. We have been unable to determine the current status of this population. In 1976 an adult caiman with several young perched on its back was spotted near Coopertown on the Tamiami Trail (J. Wasilewski, pers. comm.). In 1980 a series of hatchling caimans were collected near the same locality (R. McDermott, pers. comm.). Ellis (1980) reported an established and breeding population confined to the canal system on the Homestead Air Force Base; the population was first discovered in 1974. Efforts have been made to extirpate this population, but have not been completely successful.

Pseudemys scripta.—Three subspecies of the slider presumably have been reported introduced into south Florida. King and Krakauer (1966) reported *Chrysemys* (=*Pseudemys*) *s. elegans* as established but not breeding and *C. s. callirostris* and *C. s. ornata* as not having been seen again after their initial release. Specimens of the latter two subspecies were stated to have been released into the Red Road Canal at W. 27th Street in Hialeah. We have visited that locality several times without seeing any of these turtles. On the other hand, *P. s. elegans* (Fig. 31) is known to have been established

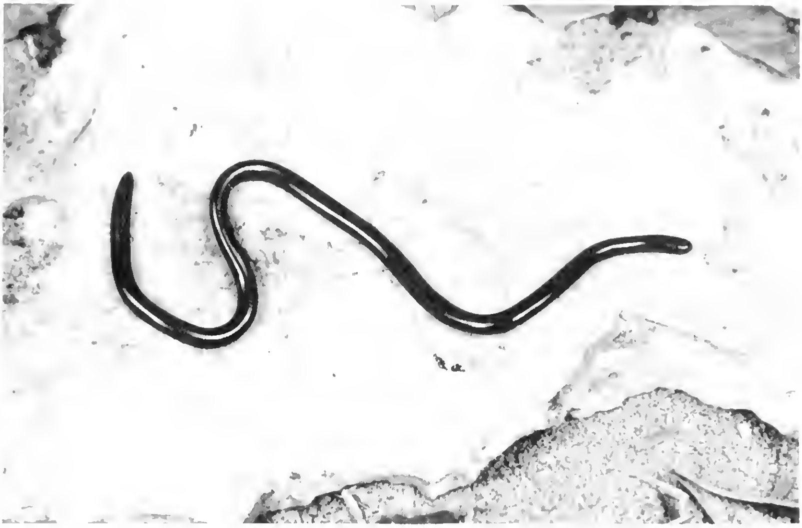

FIGURE 32. Brahminy Blind Snake (*Ramphotyphlops bramina*). (LP)

and breeding since at least 1958 by one of us (LP); it occurs in canals throughout the Metropolitan Dade County area.

Ramphotyphlops bramina.—No exotic snake has previously been recorded as established in the continental United States. Myers (1958) mentioned the possible introduction of *Typhlops lumbricalis* into south Florida, based on a single specimen collected in 1930, but the species has not been found since. We herein report the introduction of the Brahminy blind snake in three separate localities in Dade County. *Ramphotyphlops bramina* (Fig. 32) is the most widely-distributed terrestrial snake in the world (McDowell 1974). It is pantropical, occurring in many far-flung areas, including Hawaii. It has been introduced in Baja California del Sur, Guerrero, Michoacán, and Sinaloa, México (Smith and Smith 1976; Murphy and Ottley 1979). In April 1979, the late Phil Bennett presented us with several of these snakes, which he collected in the vicinity of S.W. 63rd Court and 64th Street in South Miami. He subsequently collected a series of additional specimens in the same vicinity indicating that this parthenogenetic species is well-established in a residential area. In late 1980 two others were found by a telephone company crew during excavation activities at E. 56th Street and 42nd Avenue near the Amelia Earhardt Air Base. In December 1981, a specimen was found in a vacant lot between the Palmetto Expressway and Hialeah Speedway north of Okeechobee Road in Hialeah. These three localities are widely separated; the second locality is near the site of a weekend swap meet where plants are sold.

In summary it appears that most of the 24 exotic species and the single native transplant which are established and breeding in south Florida were introduced either as stowaways or as a result of accidental or purposeful release by an animal dealer or the subsequent recipient of the animal(s). Other species were also introduced as a result of escape from zoological parks or other exhibits, or through release by individuals not connected with the animal trade. In addition, there are a few species (or populations of species) whose means of origin remain unknown. Although the manner of introduction of certain exotic species is nebulous, our best guesses follow. We are listing some species in more than one category, because there are populations that obviously arrived by different methods of introduction.

We believe that the following ten species of exotic animals were introduced as stowaways through the shipping of produce or other commodities, or the plant trade:

Eleutherodactylus planirostris
Osteopilus septentrionalis
Anolis distichus (*dominicensis*)
Anolis sagrai
Gonatodes albogularis
Hemidactylus garnotii (Hialeah population)
Hemidactylus turcicus
Sphaerodactylus argus
Sphaerodactylus elegans
Rhamphotyphlops bramina

A second major group includes nine species that were released by animal dealers or subsequent purchasers, as follows:

Bufo marinus
Ameiva ameiva (Hialeah and Suniland populations)
Basiliscus vittatus
Cnemidophorus lemniscatus
Gekko gecko
Iguana iguana (airport population)
Leiocephalus schreibersi
Caiman crocodylus
Pseudemys scripta

A third group consists of four lizards introduced by individuals who were not associated with the animal trade:

Anolis cybotes
Anolis equestris
Leiocephalus carinatus (Palm Beach population)
Hemidactylus garnotii (South Miami/Coconut Grove populations)

A fourth group is composed of three lizards released from zoological parks or exhibits and includes:

Ameiva ameiva (Key Biscayne population)
Iguana iguana (Key Biscayne and Virginia Key populations)
Leiocephalus carinatus (Virginia Key population)

A final group includes four lizards or populations of lizards whose method of origin of introduction remains unknown. They consist of:

Anolis garmani
Anolis cristatellus
Ctenosaura pectinata
Leiocephalus carinatus (Port of Miami population)

We suspect, however, that the two anoles and the curly-tail were introduced as stowaways and the ctenosaur as a result of the animal trade.

It is possible that some recent introductions (e.g., *Anolis sagrai, Hemidactylus garnotii, H. turcicus*), especially of populations found outside of our study area, may have resulted from individuals transported from their native range or elsewhere via shipping, as opposed to spread from other introduced populations in Florida.

We have decided not to consider a number of alien species which, although introduced into south Florida, have not established breeding populations. It is important to note, however, that one particular area of the city (vicinity of N.W. 70th Street and 70th Avenue) where *Basiliscus vittatus* and *Leiocephalus schreibersi* were known to occur, was inundated by other exotic species releases. This area has now been demolished to allow for construction of a link in a rapid transit system, so it is unlikely that any of these "released" species, unless transported elsewhere, have survived. We originally intended to report a colony of *Agama agama* from this area, established since 1976, but we are now virtually certain that it did not survive the demolition.

DISCUSSION

South Florida is approaching ecocollapse. The ecological systems of south Florida are so imperiled that unless significant steps are quickly taken to halt ecosystem manipulation, the life support systems of the southern peninsula will be extinguished. From a naturalist's point of view, the Atlantic coastal ridge is dead, large sections of the Everglades have become dehydrated, and the Everglades National Park is struggling for its existence. Although a few years behind the east, the west coast seems inevitably to be following the same uncontrolled pattern of growth. The subtropical majesty of the Florida Keys is succumbing to a seemingly terminal malignant growth syndrome.

Our intention in writing this paper has been to focus attention on the nefarious impact of humans on the south Florida ecosystem, based on what is happening to the animal group we know best—the herpetofauna. It is our hope that our work will augment efforts to bring relief to this beleaguered area, and help to rescue it from the constant undermining of its ecological framework. The string of

FIGURE 33. Rocky canal dike in western Dade County commonly inhabited by *Elaphe guttata* as well as other snakes. In recent years extensive portions of such dikes have been hauled away for use in constructing roadbeds and housing foundations. (LP)

sleepy little towns, which comprised the urban areas of southeastern Florida in the 1940's and 1950's, deserved a better fate than the development that overtook them in the 1960's and then exploded completely out of hand in the 1970's. Their sad fate is one that will be duplicated anywhere that undisciplined and unlimited growth is allowed to occur. We must learn these lessons.

Our concern for these problems has resulted in part from our interest in assessing man's impact on the area's native amphibians and reptiles. From the data we have presented, it is obvious that the *major* factors acting to reduce native amphibian and reptile populations are destruction of natural cover and manipulation of the hydrologic cycle. This statement cannot be too strongly emphasized.

Additional pressures on the indigenous herpetofauna exist, but their importance is insignificant when compared with the two major sources of environmental pressure. The additional pressures, listed in what we believe to be their decreasing order of importance, include: (1) destruction of man-made cover; (2) naturalization and spread of injurious exotic plants; (3) vehicular traffic; (4) biocides and other forms of pollution; (5) man-generated fires; (6) outright killing; (7) collecting; and (8) competition with exotic amphibians and reptiles.

FIGURE 34. The "devil catcher," used to control plant growth along canal banks in western Broward and Palm Beach counties, leaves a path of destruction in its wake. (JR)

Once the natural cover of an area has been removed, there are a number of native amphibians and reptiles that will become established in the newly-created niches if the land is allowed to lie fallow. Secondary growth and an accumulation of discarded objects provide favorable habitat for insects and rodents which, in turn, provide food for frogs, toads, lizards, and snakes. Eventually most of the altered areas are plowed for cultivation or bulldozed for housing, which to use a colloquialism, gives these animals the "double whammy." A similar situation occurs when rows of old Australian pines are cut down, when rocky canal dikes (Fig. 33) are hauled away for use as fill, when tractors pulling staggered series of large bladed rollers called "devil catchers" (Fig. 34) devastate rocky canal banks in order to root up plant growth, and when canals are dredged by boats to remove aquatic weeds.

Two of the three terrestrial injurious exotic plants of concern (i.e., *Melaleuca* and *Schinus*) are trees, which in south Florida, create a monobiotic environment that lacks the diversity necessary to support a complex herpetofauna. The third plant, *Casuarina*, has proved detrimental for certain native amphibians and reptiles, but has also been a salvation for others. Of the two aquatic injurious plants,

FIGURE 35. Road kills of at least five snake species found during the spring of 1979 on about twelve feet of the Tamiami Trail at the entrance to the Everglades National Park at Shark Valley, western Dade County. (LP)

Hydrilla physically fills up the space in the water that it occupies, thereby reducing the space utilized by other aquatic organisms. Water hyacinths, on the other hand, blanket the surface of the water and are especially harmful to wet-adapted species that occupy shallow ponds for breeding during the spring. An additional factor of concern is that both plants are disruptive to natural food chains.

Vehicular traffic has long been known as an important agent in reducing populations of amphibians and reptiles. The impact was noted by Barbour (1944) when he stated that "... in Florida the slaughter of reptilian life on the roads has been devastating, and the reason is clear. There are cold spells, sharp northers, bringing the temperature down to frost or near freezing. Normal temperatures return in a few hours and then the snakes and tortoises creep out on the black tarred road to warm up. There they have been killed literally by millions. I mean what I say, and I am not exaggerating, for Florida is a very large state." In south Florida, road kills are found throughout the year, especially on those roads traversing the Everglades (e.g., the Tamiami Trail and Alligator Alley). During the spring, however, following a "normal" winter (i.e., where manipulation by the Central and Southern Flood Control District approximates natural water levels), species that have survived or, in some cases, have taken advantage of hydrographic manipulation, congregate for breeding at small pools and ditches, particularly those formed at road culverts. Countless numbers are slaughtered by vehicles as they cross the highways (Fig. 35).

South Florida is one of the most pesticide-sprayed regions in the world. "Roughly two million pounds of chemicals each year are spread over Dade County alone, more than a pound per person" (Dorschner 1980). Biocides are commonly used in agriculture for controlling pests and weeds, and also for the suppression of aquatic weeds in waterways and mosquitoes in inhabited areas. During rains the biocides run off into nearby canals, contributing to the status of Miami's drinking water as "one of the most chemically contaminated of any city in the country" (Boyle and Mechem 1981). Obviously, these pollutants have taken their toll of amphibian and reptile populations. For example, extensive fish, amphibian, reptile, bird, and mammal kills frequently occur in northwestern Broward County as a result of pesticides sprayed from airplanes onto sugar cane fields to control rodents. Also, the Miami River and much of the network of drainage canals in southeastern Florida are so polluted that the native amphibians and reptiles once found there have been largely extirpated.

Chemical contamination of water by biocides is not the only thing affecting south Florida's water quality. In November 1981, the Miami-Dade Water and Sewer Authority began adding liquid anhydrous ammonia to chlorinated drinking water supplies. The ammonia and chlorine react in water to produce the chemical compound chloramine. This procedure was initiated as a cheap method to comply with a federal mandate to rid the drinking water of carcinogenic trihalomethanes. Soon thereafter, however, hundreds of thousands of dead fish were reported by tropical fish aquarists and suppliers. In addition, reptile dealers were faced with heavy losses among amphibians and turtles, especially softshell turtles (*Trionyx*). Our preliminary observations indicate that plants may be adversely affected by chloramine-contaminated water. As is often the case, we have another example of materials being introduced into the environment before adequate testing has been carried out, with the possibility of massive damage being done to organisms that are part of aquatic food chains in south Florida. Chloramine, itself possibly carcinogenic, nonetheless, is still present in Dade County's water supply, and its use is spreading to other areas of the country.

The manhandling of the hydrologic cycle in south Florida is especially obvious during the dry season in years of drought. Water, shuttled off to agricultural and urban areas through the 1400-mile network of drainage canals, leaves the Everglades parched and subject to devastating fires that sweep through tens of thousands of acres of supposed wetlands. The toll taken during very dry years is tremendous (Ward 1972), but large numbers of fires occur every year. After such conflagrations the charred remains of the herpetofauna, especially reptiles, are often encountered, and for years thereafter the areas remain virtually devoid of amphibian and reptile life.

The ignorant and fearful attitude of the layman toward amphibians and reptiles is well-known. Weekends, holidays, and the hunting season are times when there is an exodus of armed people from urban centers into the Everglades in their swamp-buggies, half-tracks, and airboats, ostensibly for fishing and hunting. Unfortunately, the result of such activities is often a trail of maimed and slaughtered wildlife of all descriptions. Even a share of the hunters themselves do not manage to escape the barrage.

Most people who develop an interest in herpetology begin by collecting specimens in the out-of-doors. Later, their interests will usually begin to diverge. Some become hobbyists, others develop a scientific interest, and a few people collect these animals as a livelihood. South Florida has long been an important wildlife import-export center and animal dealers have been willing to purchase most species of local amphibians and reptiles for resale. Over the years, commercial collecting must have had an impact on the populations of some native south Florida herpetozoans, but it is interesting to note that currently the native species most favored by such collectors are those whose populations remain relatively stable. In recent years there has been a trend toward a reduction in the number of full-time commercial collectors, as well as the orientation of part-time collectors toward collecting introduced species within the city. Private and scientific collecting has been so minimal as to be hardly worthy of mention. Albert Schwartz, in an address read at an Exotic-Nonnative Species Conference held in April 1979, at the Florida Atlantic University in Boca Raton, noted that "animals themselves have rarely (if at all) been overcollected for commercial or scientific reasons; rather, the tremendous growth of Miami as a prime Sun Belt city has caused habitat destruction with its companion destruction of animals and plants."

We consider competition of exotic species of amphibians and reptiles with native ones to be the least important factor in reducing the latter's populations. Since the publicity surrounding this matter has been so overwhelming, however, and because the potential exists for escalation of the importance of the problem, we have decided to consider it at length in the following sections.

Patterns of amphibian and reptile introductions.—There is no way of telling how long introductions of amphibians and reptiles into areas outside their natural range have been occurring. Some introductions have been purposeful but most, undoubtedly, have been accidental, occurring as a consequence of shipping. Introductions have taken place world-wide in temperate and tropical regions. The giant toad (*Bufo marinus*) is an example of an amphibian that was introduced purposely for insect, rodent, or snail control. It is extremely widespread, occurring outside its natural range in such varied places as Hawaii, New Guinea, Australia, Japan, the Philippines, Fiji, Tonga, and Solomon Islands, Guam, several islands in the West Indies, and, of course, south Florida. For food, the bullfrog

(*Rana catesbeiana*) has been introduced into such areas as México, Canada, some islands of the West Indies, Japan, Italy, Hawaii, and many areas of the western United States. *Hemidactylus turcicus* is a good example of a stowaway lizard, which has become established in several states bordering the Gulf of Mexico, as well as Arizona, México, the Greater Antilles, and Panamá. *Ramphotyphlops bramina* is another example of a stowaway which has become widely distributed in Hawaii, México, Australia, Japan, southeastern Asia, and many islands of the south Pacific. This snake is now so widespread that its original range can only be approximated (McDowell 1974). Introductions have also occurred as a consequence of the animal trade. The lizard *Anolis carolinensis* is an example, now found in Japan; its close relative *A. porcatus,* native to Cuba, is introduced in Hawaii.

A large number of introductions have been reported in the United States (Smith and Kohler 1978). Most of these have taken place in four states, viz., California (Bury and Lukenbach 1976), Florida (this paper), Hawaii (McKeown 1978), and Texas (Thomas 1974; Conant 1977); a summary is found in Table 4, which also indicates that Florida harbors the greatest number of introduced species, followed by Hawaii and trailed by California and Texas. The majority of the species are native to tropical areas and most are lizards. The patterns of introduction into south Florida have already been discussed.

Commentary on literature dealing with introductions in South Florida.—Over the course of the last few years we have amassed a copious amount of popular literature dealing with exotic wildlife in south Florida. Perusal of it indicates that there is a basic theme running throughout, viz., that exotic organisms are outcompeting their native counterparts, and that the southern portion of the peninsula will eventually be overrun with these creatures. The veracity of this conclusion is open to question, and we are concerned that many statements have been made on the basis of little field or experimental data. We believe that in most cases the statements were made indiscriminately to help sell the magazines and newspapers in which these articles appeared. Many are sensational and intended to trade on the idea of an "invasion" by these organisms. Such an approach tends to obscure the biology of the introductions. An example is the situation involving cobras. The news media have often inferred that cobras are breeding in the Everglades, information which is patently false. In the early 1970's a snake handling religious sect conducted services with various species of venomous snakes, including cobras. The leader of the sect was bitten by a Florida cottonmouth and, as a result, released some native venomous snakes and two cobras, one a Siamese cobra (*Naja naja kaouthia*), the other an Egyptian cobra (*Naja haje*). The Siamese cobra was later found dead on a road traversing the Everglades, and taken to the Miami Serpentarium for identification. Some years later a Ceylonese cobra

(*Naja naja naja*) was captured within the Miami city limits and reputed by the news media to be gravid. That snake was also taken to the Miami Serpentarium, and was found to be a male (J. Wasilewski, pers. comm.). It is suspected that it had escaped from a serviceman who had recently traveled to Asia. The black cobra (*Naja melanoleuca*) has also been stated to occur in south Florida, in several popular accounts, which is equally untrue.

A further problem is that in popular articles covering several plant or animal groups, conclusions derived concerning the nature of the introductions in one group tend to be applied to the other groups, resulting in additional confusion. Exotic organisms of other kinds, notably fishes, insects, and snails have caused massive problems requiring millions of dollars in an effort to control them. We feel that there is a considerable need for ecological research in *each* biological group to elucidate the nature and consequences of introductions into south Florida.

Only two papers appearing in scientific journals have significantly addressed the question of south Florida's exotic herpetofauna. In the first, King and Krakauer (1966) summarized the information available at that time on the alien species, and the history of their introductions and subsequent spread (if any). Their paper, although it was a useful summarization of the topic, presented a somewhat exaggerated view by listing a large number of species as "unreported since release." The same species were later uncritically included by Smith and Kohler (1978) in their "exotic released" category. As an example, King and Krakauer indicated that 2361 specimens of 17 species of amphibians and reptiles were released in 1964 at an address formerly occupied by an animal dealer along the Red Road Canal in Hialeah. All 17 species were included by Smith and Kohler. We have made numerous trips to the locality and have found *no* evidence that *any* of the species have survived.

The other major paper, by Smith and Kohler (1978), which we have already mentioned, summarized amphibian and reptile introductions in the United States and Canada. Although this paper is valuable, it is deficient in two important respects. First, the information it contains is based strictly on a survey of previously published literature; it includes no original data on the introductions. The comments regarding south Florida are repetitious of those presented in 1966 by King and Krakauer, with the addition of those exotic species that had been reported in subsequent literature up to 1978. Secondly, ideas are proposed in Smith and Kohler's summary to which we take major exception. Our objections are the same as those admirably discussed, in rebuttal, by Rundquist (1978).

The issue of competition.—The principal and justifiable concern evinced in papers on introductions of exotic amphibians and reptiles into south Florida is that these alien species may enter into competition with native ones to the detriment of the latter. The question remains, however, as to whether such competition is actually occurring and what, if any, other kinds of relationships exist between the exotic and native herpetofauna and/or other organisms. The picture presented in the literature to date has been a simplistic one, limiting the impact of an exotic to interspecific competition with native species.

Competition occurs when two organisms are using the same limited resource, and may be interspecific or intraspecific. Competition can be expected to be more severe among members of the same species, because of the greater similarity of their ecological requirements. The closer two different species are in their requirements, the more severe their interspecific competition will be. The principle of mutual exclusion, however, predicts that no two species existing in the same area will have the same niche requirements, and be able to coexist for an indefinite period of time.

The question whether exotic species compete with native ones is a multifarious one. If a given exotic species is suspected of entering into competition with a native one, several questions should be raised. What are the resources they are both utilizing? If they are using the same resources, to what extent is this occurring? What are the characteristics of the exotic species that enable it to outcompete its native counterpart? What part does availability of open niches play? What part is played by the great competitor, *Homo sapiens*? These are fundamental questions that thus far have been sidestepped in the literature on the subject in south Florida. Answers are not available for all these questions, but it is our hope that our observations and conclusions will open avenues for long-term research.

To begin an analysis of these questions, it is necessary first to ask which species of exotic amphibians and reptiles are entering into competition with which native ones. If they do compete, they must occur syntopically. One way to approach this question is to note first those exotic species which, for the present and foreseeable future, are restricted in distribution to urban areas. These species have the ability to adapt to modified habitats. Also, their ability to disperse is overshadowed by the growth of the city. These species are:

Ameiva ameiva
Anolis cristatellus
Anolis cybotes
Anolis distichus dominicencis
Anolis garmani
Basiliscus vittatus
Cnemidophorus lemniscatus
Ctenosaura pectinata
Gekko gecko
Iguana iguana
Leiocephalus carinatus
Leiocephalus schreibersi
Sphaerodactylus argus
Pseudemys scripta
Ramphotyphlops bramina

Most of these are known only from urban areas of Dade County. There are a few native species that are able to exist in the same areas, but only two native lizards appear locally abundant, viz., *Anolis distichus floridanus* and *Sphaerodactylus notatus*. The remainder are only occasionally found within the confines of the city. They are:

Pseudemys floridana	*Coluber constrictor*
Pseudemys nelsoni	*Diadophis punctatus*
Trionyx ferox	*Elaphe guttata*
Anolis carolinensis	*Storeria dekayi*
Eumeces inexpectatus	*Thamnophis sirtalis*
Ophisaurus ventralis	

Of these native species, only *P. floridana*, *P. nelsoni*, and *A. carolinensis*, because of their morphological and/or ecological similarities, could conceivably come into competition with any of the exotic species that are limited to urban areas. The question as to the reality of such competition is discussed below.

The other group of exotic species are those which occur both in urban and agricultural/natural areas. These species are:

Bufo marinus	*Anolis sagrai*
Eleutherodactylus planirostris	*Hemidactylus garnotii*
Osteopilus septentrionalis	*Hemidactylus turcicus*
Anolis equestris	*Sphaerodactylus elegans*
	Caiman crocodylus

The majority of these are primarily confined to urban areas. *Eleutherodactylus planirostris*, however, is found in abundance in all three areas. *Anolis sagrai* and *O. septentrionalis* are abundant in urban and agricultural areas, and have invaded natural areas to a marginal degree. *Sphaerodactylus elegans* is primarily distributed in urban areas in the Lower Keys but is also found in quasi-natural areas as well.

At this point we have identified a group of exotic species that are restricted to urban areas, and we have presented a list of those native species whose ranges include urban conditions. We have also listed those exotic species whose ranges include both urban and agricultural/natural areas. It is now necessary to examine the possibility of competition, or threat thereof, between exotic species and certain native counterparts. These species are listed in Table 5.

The giant toad (*Bufo marinus*) is capable of undergoing population explosions in introduced situations, and its occurrence in south Florida, therefore, is a matter of serious concern. King (1968) stated that the giant toad "is replacing the native southern toad in residential areas." That this is due to direct competition seems not to be the case. According to our recollections and those of numerous long-time residents and collectors, what decimated *B. terrestris* in urban areas was its inability to adapt to changes in vegetation and water supply instituted through human agency. The departure of the

TABLE 5. Exotic and native species in south Florida between which competition may conceivably take place.

Exotic species	Native counterpart
Bufo marinus	*Bufo terrestris*
Osteopilus septentrionalis	*Hyla cinerea* *Hyla squirella*
Caiman crocodylus	*Alligator mississippiensis*
Pseudemys scripta	*Pseudemys floridana* *Pseudemys nelsoni*
Anolis cristatellus *Anolis cybotes* *Anolis distichus dominicensis* *Anolis equestris* *Anolis garmani* *Anolis sagrai*	*Anolis carolinensis* *Anolis distichus floridanus*
Sphaerodactylus argus *Sphaerodactylus elegans*	*Sphaerodactylus notatus*

southern toad from disturbed areas was followed by the intrusion of *B. marinus*. Krakauer (1968, 1970) came to the same conclusion.

Bartlett (1967) stated that the Cuban treefrog (*O. septentrionalis*) was "seriously decimating *all* native Hylas over its entire range" (in south Florida), but no supportive evidence for this statement was offered. Over the years we have witnessed the rapid expansion in range and numbers of the Cuban treefrog within urbanized areas of southern Florida. Its spread has been facilitated by the many swimming pools in the area. This frog is also commonly found in agricultural areas where it inhabits exotic trees, such as various species of *Ficus* and *Casuarina*, run-down old buildings, railroad trestles and bridges, as well as patches of disturbed vegetation. *Hyla cinerea* and *H. squirella*, the two native treefrogs with which *O. septentrionalis* is known to come into contact, occur primarily in natural areas, but also inhabit agricultural areas and urban areas where sufficient vegetational cover exists. *Hyla cinerea* and *H. squirella*, although frequently encountered, do come into contact with *O. septentrionalis*, which eats other frogs, even of its own species. This situation appears to us to have the greatest potential for displacement of the native treefrogs by the exotic one.

Caiman crocodylus and *Alligator mississippiensis* are similar morphologically and competition between the two is to be expected. Among those native species that have taken advantage of human-created niches, *A. mississippiensis*, in recent years, has shown a dramatic increase in population size and is no longer in danger of extirpation. *Caiman crocodylus* currently occurs in very restricted areas and the only natural area where the two would come into contact is near Coopertown (see species account). Although we suspect that the alligator's superiority of numbers will hold it in good stead against potential competition with the brown caiman, there is a pressing need to use the Coopertown locality to study the interaction between the two species and/or to remove the caimans from that area.

Over twenty years ago the red-eared slider, *Pseudemys scripta elegans*, was established and breeding in sizable populations containing many adult individuals. At that time *P. scripta* was found with the native *P. floridana* and *P. nelsoni*. Today all three turtles are present in urban canals and lakes, but *P. s. elegans* is no longer so abundant as it once was. Our experience indicates that *P. nelsoni* is a turtle of broader adaptability than *P. s. elegans*, and it is able to exist in polluted waters with little surrounding vegetation.

Six taxa of exotic anoles are known to occur in south Florida; two additional lizard taxa are native. Most of the literature on the introduction of anole species into south Florida has raised the specter of competition of the introduced lizards with the native *Anolis carolinensis*. The only major work dealing with this question is that of King (1966) on competition between *Anolis carolinensis* and *A. distichus* in Miami. King studied the ecology of *A. carolinensis* in a "pure" population (in an area not occupied by *A. distichus*) and compared data from there with other information gathered in an area occupied by both *carolinensis* and *distichus*. The subspecies of *A. distichus* studied is what is now called *A. d. floridanus* (Schwartz 1968). King concluded that competition does occur between these two anoles. He pointed out that *A. distichus* enjoys an advantage of greater natality but that *A. carolinensis* possesses a broader temperature regime and can move from its preferred habitat on trees and shrubs in filtered sunlight into areas of more intense sunlight. Thus, competition is minimized by these mechanisms. Similar conclusions may well apply to relationships between *A. carolinensis* and the introduced *A. d. dominicensis*. The conclusions reached by King may have been somewhat different if he had chosen to study the ecology of *A. carolinensis* in natural surroundings, instead of in an urban area. The study area he selected for studying competitive relationships between *A. carolinensis* and *A. distichus* was one of the planting areas in Fairchild Tropical Garden. Conceivably, in an artificially created environment such as this, *A. carolinensis* might be expected to operate at a disadvantage. Nevertheless, the parameters of competitive interaction studied by King could be applied to the relationships between other anoline species in south Florida.

If there are any of the introduced anoles that would appear to possess the potential for outcompeting one of the native anoles, it would seem to be the superabundant *Anolis sagrai*. To date there has been no attempt made to assess its impact on the native *A. carolinensis* in the detailed fashion of King (1966). Nonetheless, we offer a few comments based on both the literature and our own personal observations. First, *A. distichus, A. sagrai* and *A. smaragdinus* (a species closely related to *A. carolinensis*) occur syntopically as natives in many areas of the Bahamas. A similar relationship exists between *A. carolinensis, A. distichus,* and *A. sagrai* in south Florida. In Cuba, *A. sagrai* occurs syntopically with *A. porcatus,* a very close relative of (and formerly considered conspecific with) *A. carolinensis.* The interactions of those two species in both Cuba and south Florida were studied by Collete (1961). He noted that in areas of syntopy, *porcatus* and *sagrai* adjusted their perch sites to accommodate the presence of the other species. He also mentioned that "the ecology of *sagrei* [=*sagrai*] in regions of sympatry with *carolinensis* (in south Florida) does not differ noticeably from *sagrei* in the study area in Cuba." In addition, he indicated that the relative abundance of *porcatus* and *sagrai* changed depending on the amount of vegetation present from year to year. Our own observations in south Florida are in accord with Colette's conclusions. Furthermore, Schwartz, in his previously-mentioned conference address, summarized the history of the spread of *Anolis sagrai* in south Florida, noting that "the success of *A. sagrei* can by 'blamed' on open niches for an ecologically very tolerant lizard plus its ability to survive successfully under situations which other anoles would find intolerable."

We have not observed the Puerto Rican anole, *Anolis cristatellus* in contact with *A. carolinensis.* About six years ago we began observing a small population of the former species at a locality on Red Road (see species account). At that time, *A. sagrai* and *A. distichus* were both present but not abundant. During the ensuing years the populations of all three species have increased in size, although not so dramatically in the case of *A. distichus.* Unlike Brach (1977), who postulated that *A. cristatellus* would displace *A. sagrai* as the former expands its range, we find the two species coexisting to the point of occurring together on the same branch.

The population of *Anolis cybotes* in south Florida has been under observation for several years by Lewis Ober, who has informed us (pers. comm.) that this Haitian Anole lives in contact with *A. carolinensis* and *A. sagrai* and has displaced neither. *Anolis carolinensis* is not common, but its relative abundance apparently has not changed since *A. cybotes* became established.

Little information is available on the two giant anoles, *Anolis garmani* and *A. equestris,* in terms of their competitive relationships. They are very different morphologically from the native anoline species, and the possibility of competition would appear to be greater between the two of them than between either and a native anole. At any rate, *A. carolinensis* is not abundant in the city as already noted, whereas *A. distichus* is very common.

Sphaerodactylus notatus is a common gecko along the eastern edge of the rock ridge in Dade County and throughout the Florida

Keys. Wherever found, it is abundant. *Sphaerodactylus elegans*, although it occupies the same microhabitat in the Lower Keys, is noticeably less abundant. *Sphaerodactylus argus* appears to be barely maintaining itself in restricted areas in Key West. We doubt whether these introduced lizards will offer any threat of serious competition to *S. notatus*.

There is another native lizard that shows some resemblance in ecological and/or morphological characteristics with two of the other exotic species. The six-lined racerunner (*Cnemidophorus sexlineatus*) might be expected to compete with *C. lemniscatus* or *Ameiva ameiva*. *Cnemidophorus sexlineatus* prefers habitats with sandy soils and its numbers decreased dramatically coincidental with the increased housing development, long before the exotic teiids became established. The six-lined racerunner, however, is abundant in other portions of the peninsula, particularly the Florida Keys. *Cnemidophorus lemniscatus* and *A. ameiva* occur only in restricted areas within the city. If *C. lemniscatus* or *A. ameiva* were introduced into sandy areas on the Keys, however, they could present a threat to *C. sexlineatus*.

In summary, we believe that, in light of all the environmental pressures impinging upon the populations of native amphibians and reptiles, the issue of competition between exotic and native species has been largely overplayed. The other pressures we have discussed are either well-documented or abundantly evident. Evidence of competition between native and introduced species, on the other hand, remains scant. Competition between species for limited resources is, after all, only one possible outcome of the introduction of one ecologically similar species into the range of another. There are any number of ways in which the ecological requirements of one species may be accomodated with those of another, such as spatial or temporal displacement, shift of food preferences, and so forth. The pattern we have observed, however, involves the disappearance of most of the native species concurrent with the advance of the city, and the subsequent influx into the vacated areas by the various exotic species. Of additional interest is the fact that some exotic species are preyed upon by native forms. For example, the ringneck snake (*Diadophis punctatus*) preys on the greenhouse frog (*Eleutherodactylus planirostris*) and the racer (*Coluber constrictor*) has been observed to feed on young *Ameiva ameiva*. More importantly, the Lower Keys population of the corn snake (*Elaphe guttata*) has steadily grown in urbanized areas as a direct result of the increase in the numbers of *Anolis sagrai*. Curiously enough, members of the *Ameiva ameiva* population of Key Biscayne have been observed to feed on the eggs of *Iguana iguana*. *Anolis equestris* also preys on *Osteopilus septentrionalis* and *Anolis sagrai*, as well as exotic vegetation. *Ctenosaura pectinata* is known to feed on the fruit and leaves of various exotic trees.

The influence of the south Florida climate on the dispersal of exotic herpetofauna.—The Climate of south Florida, though subtropical, is not uniform throughout the area. Hela (1952) pointed out a distinction between the climate of the coastal region of southeastern Florida and the inland areas to the west. The coastal region is under the moderating maritime influence of annual temperature extremes. The fact that the temperature parameters along the southeastern coast are narrower than along the southwestern coast results from the effect of continentality, i.e., their proximity to a large continental mass and its influence on increasing the annual temperature range. Also, there is the moderating effect of the prevailing easterly trade winds along the southeastern coast. As a result, the coastal area of southeastern Florida, according to Hela, possesses a "monsoon rainforest climate", which is "an intermediate climate type between the tropical rainforest climate and the tropical savanna climate" characterized by the presence of forest vegetation in spite of a dry season. The remainder of the peninsula has a "tropical savanna climate" with a "relatively long and severe dry season" with rainfall amounts insufficient to compensate for the drought; it supports more open forest and tall grass (or sedges).

Studies on the relationships between climatic differences in south Florida and the distribution and dispersal of introduced amphibians and reptiles are few. Only Krakauer (1968, 1970) has commented on this matter. He pointed out that the more extreme inland temperatures and more frequent, longer widespread frosts could well limit the expansion of the range of the giant toad (*Bufo marinus*). Krakauer (1968) determined the 96 hour LT_{50} for marine toads from Miami to be about 5°C. Muscle tonus was lost after 12 hours at 4.2°C. Krakauer (1970) indicated, however, that *B. marinus* "will probably spread a long way up coastal Florida, because of the mild temperatures and the protection from cold provided around houses."

Some exotic amphibians and reptiles have expanded their ranges into north-central Florida and along both coasts, but for the majority of the south Florida exotics the cold winter temperatures in the Everglades and to the north of Lake Okeechobee probably will prove to limit their dispersal. Barbour (1944) noted that after the digging of numerous drainage canals "the size of Lake Okeechobee was greatly reduced and the warm waters were drained from the Everglades. Since these waters were a God-given aid in warming the air when cold northwest winds swept down, the climate of southeastern Florida changed for the worse." Because of the continued manipulation of the area's water supply, the situation can be expected to worsen. The changing weather patterns in recent years, such as colder winter temperatures and even snow, as well as the extended, severe droughts which have brought the water level in Lake Okeechobee to its lowest point in history, seem to confirm what Barbour said four decades ago.

Additional considerations and recommendations.—In 1979 a conference held at Florida Atlantic University, concerned with exotic vertebrates in Florida, was sponsored by the Florida Audubon Society and the State of Florida Game and Fresh Water Fish Commission. The papers presented at the conference summarized the extent of our knowledge concerning the various groups of introduced vertebrates. The pattern of competitive interactions between exotics and their native counterparts was shown to be distinct in each vertebrate group examined. A powerful undercurrent existed at the meeting to the effect that introduction of exotic creatures into Florida would cause increasing threats to the survival of native representatives of those same groups, and that efforts should be directed toward control of the situation. The consensus was that legislation should be enacted to place tighter restrictions on animal ownership, primarily by prohibiting or severely limiting the importation of exotic wildlife, and by initiating eradication programs for established populations of exotic vertebrates.

We consider these proposed solutions to be too simplistic, because they are directed toward one of the most easily identified but least important exacerbating agents. The major factors, which we have already identified, were essentially ignored except in our own presentation on the alien amphibians and reptiles. Exotic organisms have become established in Florida through several different means, and not simply by the release or escape of imported animals. For example, the immigration of stowaways is virtually impossible to control. Governmental agencies also have a long history of intentional exotic introductions. Furthermore, it is difficult for anyone, not directly involved in the animal trade, to vizualize the importance of supplying animals to organizations and individuals engaged in educational, biological, and medical research. More importantly, we believe that the status of an organism as an exotic should not be the sole criterion used to judge the need for its prohibition.

As we have pointed out, the animal trade has been responsible for numerous introductions. Obviously, there is a need for the appropriate authorities to monitor animal compounds, pet shops, and animal exhibits to assure that escape-proof facilities are utilized. It is also necessary that owners and employees of such establishments be educated as to the problems inherent in the release of exotic wildlife into the environment. The release of exotic animals by private individuals is more difficult to prevent. Most assuredly, there are irresponsible people who have and will continue to release exotic animals. Governmental agencies need to initiate a propaganda program for the distribution of literature to animal businesses which in turn should be passed on to the purchaser of an exotic animal.

Perusal of the list of species suspected to have been introduced as a consequence of the animal trade indicates that *all* were imported, at one time or another, in large numbers to be sold for a relatively cheap price. Obviously, the greater the number of specimens of each species imported and the lower their sale price, the greater the chance that either the importer or the buyer will be instrumental in their release. Would not a quota system for the importation of non-native amphibians and reptiles help to curb such releases? A quota system would have the effect of raising prices, reducing the loss of animals from their native populations, and suppressing the likelihood of releases by the animal dealers or the animal's eventual owner.

Over the years we have been aware that a few thoughtless people have purposefully liberated exotic venomous snakes into the environment. Some of them had been issued a license to possess venomous reptiles by the State of Florida Game and Fresh Water Fish Commission. The regulations governing the possession of venomous reptiles, for the most part, are well-constructed, but they appear to have one major flaw. A sufficiently stringent screening process for permit applicants is not practiced. In some cases, permitees are not of legal age or are people who have only a meagre knowledge of venomous reptiles and the responsibilities involved with their possession. Thus the issuance of permits actually constitutes a menace to themselves and to others. Our suggestion to curb this problem would be for the game officials to require that permitees be of legal age, be able to prove sufficient expertise for housing the animals, and agree that the exotic venomous reptile(s) will not be liberated into the environment. It should be understood that any such agreement would be legally binding and that its violation would constitute a criminal offense.

Characteristically, once an exotic organism is known to be released and/or established, the question has arisen as to how these creatures can be eradicated. In the well-publicized case of the giant African snail, which became established in Miami in 1966, an eradication program, although costing nearly one million dollars, was successful, largely because the organism was confined to a limited area. Attempts to eradicate various exotic organisms have involved the use of chemicals, outright killing, importation of appropriate predators, parasites, or disease organisms from the animal's homelands, or concerted collecting efforts. The problems with eradicating the established exotic amphibians and reptiles, however, are augmented because so many species have become so widely distributed. If a program for the eradication of introduced herpetofauna is seriously considered, we believe that the following questions should be asked:

1. Is there documented proof that the species in question is outcompeting native counterparts or otherwise disrupting natural ecosystems?
2. Could the eradication campaign prove harmful to native species?

3. Are there signs that the campaign would prove to be costly and time-consuming only to be futile?
4. Is the eradication of the species morally defensible?

This last consideration, philosophical though it may be, is one we think of paramount importance. Is it morally defensible for a human being to attempt to eliminate a creature that is here because it was brought here? Is not man, after all, the prime culprit in the destruction of our natural heritage?

Instead of investing in programs of eradication, another approach would be to accept the animals to constitute part of the *new urban* herpetofauna, and to recognize their potential as a source of biological material for scientific, medical, and educational study. For example, the giant toad (*Bufo marinus*) is imported into this country in enormous quantities to fill the needs of biological and medical institutions. If a quota system, such as we have suggested, were to be put into effect, then animal dealers would have to turn to introduced populations to meet their needs. Although it is unlikely that this procedure would assure the disappearance of these populations, it would certainly be a step in the right direction and might eventually serve as a control.

We consider that there is an important need for research on the biology of non-native species, especially in terms of possible competition with native species in natural habitats, as well as in their ability to disperse from urban into natural areas. Thorough ecological surveys of certain areas are needed in order to provide data to permit the establishment and maintenance of critical habitat for members of the native biota, and to assure the protection of such areas from further molestation by people.

Our last and most critical recommendation is that steps be taken immediately to establish procedures for placing limits on the human populations in south Florida and the consequent development intended to support this burgeoning population. We can only reiterate the conclusions of the South Florida Study (Browder, Littlejohn, and Young 1977), which indicated at the time the study was completed (about 1973), that south Florida was approaching or had reached its carrying capacity for *Homo sapiens*. Growth has continued, of course, and the situation has become more critical. The time to act is now; our natural heritage and our children cannot afford our procrastination.

LITERATURE CITED

ALLEN, E. R. and NEILL, W. T.
1953. The treefrog, *Hyla septentrionalis*, in Florida. Copeia, 1953(2):127–128.

ANONYMOUS
1978. 140 years of growth: A new monograph has a profile of the population history of every Florida county. Florida St. Univ. Bull., 4(2):5–6.

AUSTIN, D. F. and SCHWARTZ, A.
1975. Another exotic amphibian in Florida, *Eleutherodactylus coqui*. Copeia, 1975(1):188.
AUSTIN, S.
1977. Exotics. Pp. 430–432. *In* Morris, A., The Florida Handbook, 1977–1978 (q.v.).
1975. Exotics. Florida Natur., 48(3):2–5.
BADER, B.
1976. A turtle paradise. St. Louis Herpetol. Soc. Newsletter, 3(7–8):7–9.
BALLINGER, K.
1936. Miami millions. Franklin Press, Inc., Miami, Florida.
BARBOUR, T.
1910. *Eleutherodactylus ricordii* in Florida. Proc. Biol. Soc. Washington, 23: 100.
1931a. A new North American lizard. Copeia, 1931(3):87–89.
1931b. Another introduced frog in North America. Copeia, 1931(3):140.
1936. Two introduced lizards in Miami, Florida. Copeia, 1936(2):113.
1944. That vanishing Eden. Little, Brown and Co., Boston.
BARTLETT, R. D.
1967. Notes on introduced herpetofauna in Dade County, Florida. Bull. Pacific Northwest Herpetol. Soc., 2(2):5–7.
1980. Non-native reptiles and amphibians in Florida. Western Massachusetts Herpetol. Soc. Bull., 1978–79:7–11.
BELL, L. N.
1953. Notes on three subspecies of the lizard *Anolis sagrei* in southern Florida. Copeia, 1953(1):63.
BISCOE, A. B., JR., JONES, E. C. and MOODY, D. L.
1967. Florida statistical abstract, 1967. Bur. Econ. Bus. Res., Coll. Bus. Admin., Univ. Florida, Gainesville.
BOYLE, ROBERT H. and MECHEM, R. M.
1981. There's trouble in paradise. Sport's Illustrated, 54(6):82–86, 88, 90, 93–94, 96.
BRACH, V.
1976. Habits and food of *Anolis equestris* in Florida. Copeia, 1976(1):187–189.
1977. Notes on the introduced population of *Anolis cristatellus* in south Florida. Copeia, 1977(1):184–185.
BROWDER, J., LITTLEJOHN, C. and YOUNG, D.
1977. South Florida: Seeking a balance of man and nature. Florida Dept. Admin., Tallahassee.
BROWN, M. T.
1976. Lee County: An area of rapid growth. A report of the South Florida Environmental Study. Center for Wetlands, Univ. Florida and Florida Division of State Planning, Tallahassee.
BROWNE, J. B.
1973. Key West, the old and the new. Univ. Florida Press, Gainesville.
BURNS, J. F.
1975. Patterns and characteristics of migration into Florida. Economic Leaflets, Bureau Econ. Bus. Res. Univ. Florida, 34(8):1–4.
BURY, R. B. and LUCKENBACH, R. A.
1976. Introduced amphibians and reptiles in California. Biol. Conserv., 10:1–14.
CARR, A. F., JR.
1939. A geckonid lizard new to the fauna of the United States. Copeia, 1939(4): 232.
1940. A contribution to the herpetology of Florida. Univ. Florida Publ. Biol. Sci. Ser., 3(1):1–118.

Carr, A. and Goin, C. J.
1955. Guide to the reptiles, amphibians and fresh-water fishes of Florida. Univ. Florida Press, Gainesville.
Carter, L. J.
1974. The Florida experience: Land and water policy in a growth state. John Hopkins Univ. Press, Baltimore, Maryland.
Colette, B. B.
1961. Correlations between ecology and morphology in anoline lizards from Havana, Cuba and southern Florida. Bull. Mus. Comp. Zool., 125(5): 137–162.
Collins, J. T., R. Conant, J. E. Huheey, J. L. Knight, E. M. Rundquist and H. M. Smith.
1982. Standard common and current scientific names for North American amphibians and reptiles. SSAR Herp. Circ., 12:1–28.
Conant, R.
1975. A field guide to reptiles and amphibians of eastern and central North America. Houghton Mifflin Co., Boston.
1977. The Florida water snake (Reptilia, Serpentes, Colubridae) established at Brownsville, Texas, with comments on other herpetological introductions in the area. J. Herpetol., 11(2):217–220.
Cope, E. D.
1875. Check-list of North American Batrachia and Reptilia. Bull. U.S. Nat. Mus., 1:1–104.
1889. The Batrachia of North America. Bull. U.S. Nat. Mus., 34:1–525.
Corwin, C. M., Linzey, A. V. and Linzey, A. W.
1977. Geographic distribution: *Anolis sagrei sagrei*. Herpetol. Rev., 8(3):84.
Craighead, F. C.
1971. The trees of south Florida. Univ. Miami Press, Coral Gables, Florida.
Dalrymple, G. H.
1980. Comments on the density and diet of a giant anole, *Anolis equestris*. J. Herpetol., 14(4):412–415.
Dietrich, T. S.
1979. The urbanization of Florida. Pp. 519–520. *In* Morris, A., The Florida Handbook, 1979–1980 (q.v.).
Division of Population Studies, Bureau of Economic and Business Research
1978. Florida estimates of population, July 1, 1977: States, counties and municipalities. Univ. Florida, Gainesville.
Dorschner, J.
1980. Don't worry. It may be at least 10 years before they know if this stuff kills us. Miami Herald Tropic Magazine, May 4, 1980:14–20, 38.
Duellman, W. E. and Crombie, R. I.
1970. *Hyla septentrionalis*. Cat. Amer. Amphib. Rept.: 92.1–92.4.
Duellman, W. E. and Schwartz, A.
1958. Amphibians and reptiles of southern Florida. Bull. Florida St. Mus., 3(5): 181–324.
Dunson, W. A.
1981. Behavioral osmoregulation in the Key Mud Turtle, *Kinosternon b. bauri*. J. Herpetol., 15(2):163–173.
Eggert, J.
1978. The invasion of the wish willy. Florida Wildlife, 31(5):9–10.
Ellis, T. M.
1980. *Caiman crocodylus*: An established exotic in south Florida. Copeia, 1980(1):152–154.
Fairbridge, R. W.
1974. The Holocene sea-level record in south Florida. Pp. 223–232. *In* Gleason, P. J. (ed.), Environments of South Florida: Past and Present. Miami Geol. Soc. Mem. 2.

Fernald, E. A.
1972. Florida: Its problems and prospects. Trend House, Tampa, Florida.
Fowler, H. W.
1915. Cold-blooded vertebrates from Florida, the West Indies, Costa Rica, and eastern Brazil. Proc. Acad. Natur. Sci. Philadelphia, 67:244–269.
Funk, R. S. and Moll, D.
1979. Geographic distribution: *Anolis s. sagrei*. Herpetol. Rev., 10(3):102.
Garman, S.
1887. On West Indian reptiles. Iguanidae. Bull. Essex Inst., 19:1–26.
Godley, J. S., Lohrer, F. E., Layne, J. N. and Rossi, J.
1981. Distributional status of an introduced lizard in Florida: *Anolis sagrei*. Herpetol. Rev., 12(3):84–86.
Goin, C. J.
1947. Studies on the life history of *Eleutherodactylus ricordii planirostris* (Cope) in Florida with special reference to the local distribution of an allelomorphic color pattern. Univ. Florida Press, Gainesville.
Gore, R.
1976. Florida, Noah's Ark for exotic newcomers. Nat. Geogr., 150(4):538–559.
Graham, E. D., Jr. and Schwartz, A.
1978. Status of the name *Sphaerodactylus cinereus* Wagler and variation in "*Sphaerodactylus stejnegeri*" Cochran. Florida Sci., 41(4):243–251.
Hela, I.
1952. Remarks on the climate of southern Florida. Bull. Marine Sci. Gulf Carib., 2(2):438–447.
Hoffmeister, J. E.
1974. Land from the sea. Univ. Miami Press. Coral Gables, Florida.
Hollingsworth, T.
1949. History of Dade County, Florida. Parker Art Printing Association, Coral Gables, Florida.
Jones, E. C. (ed.)
1971. Florida statistical abstract, 1971. Univ. Florida Press. Gainesville.
King, W.
1960. New populations of West Indian reptiles and amphibians in southeastern Florida. Quart. J. Florida Acad. Sci., 23(1):71–73.
1968. As a consequence many will die. Florida Natur., 41(3):99–103, 120.
King, W. and Krakauer, T.
1966. The exotic herpetofauna of southeast Florida. Quart. J. Florida Acad. Sci., 29(2):144–154.
Kluge, A. G. and Eckardt, M. J.
1969. *Hemidactylus garnotii* Dumeril and Bibron, a triploid all-female species of geckonid lizard. Copeia, 1969(4):651–664.
Krakauer, T.
1968. The ecology of the Neotropical toad, *Bufo marinus*, in south Florida. Herpetologica, 24(3):214–221.
1970. The invasion of the toads. Florida Natur., 43(1):12–14.
Lehman, M. E.
1976. Collier County: Growth pressure in a wetlands wilderness. A report of the South Florida Environmental Study. Center for Wetlands, Univ. Florida and Florida Division of State Planning, Tallahassee.
Lee, D. S.
1969. Treefrogs of Florida. Florida Natur., 42(3):117–120.
Love, W. B.
1978. Observations on the herpetofauna of Key West, Florida, with special emphasis on the Rosy Rat Snake. Bull. Georgia Herpetol. Soc., 4(1): 3–8.

LYNCH, J. D. and SMITH, H. M.
1964. Tooth replacement in a senile lizard, *Anolis equestris* Merrem. Herpetologica, 20(1):70–71.
McCOY, C. J.
1970. *Hemidactylus turcicus.* Cat. Amer. Amphib. Rept.:87.1–87.2.
1971. New Records: *Hemidactylus turcicus.* Herpetol. Rev., 3(5):89.
1972. New Records: *Hemidactylus garnoti.* Herpetol. Rev., 4(1):23.
McDOWELL, S. B.
1974. A catalogue of the snakes of New Guinea and the Solomons, with special reference to those in the Bernice P. Bishop Museum. Part 1 Scolecophidia. J. Herpetol., 8(1):1–57.
McKEOWN, S.
1978. Hawaiian reptiles and amphibians. Oriental Publishing Co., Honolulu, Hawaii.
MERRILL, R.
1977. Tropical cyclones affecting Miami—1876–1976. Mimeograph.
MEYLAN, P.
1977a. Geographic distribution: *Anolis sagrei.* Herpetol. Rev., 8(2):39.
1977b. Geographic distribution: *Hemidactylus turcicus.* Herpetol. Rev., 8(2):39.
MITCHELL, J. C. and HADLEY, W. B.
1980. Geographic distribution: *Hemidactylus garnoti.* Herpetol. Rev., 11(3): 80.
MORRIS, A. (ED.)
1949. The Florida handbook, 1949–1950. Peninsular Publ. Co., Tallahassee, Florida.
1977. The Florida handbook, 1977–1978. Peninsular Publ. Co., Tallahassee, Florida.
1979. The Florida handbook, 1979–1980. Peninsular Publ. Co., Tallahassee, Florida.
MURPHY, R. W. and OTTLEY, J. R.
1979. Geographic distribution: *Ramphotyphlops braminus.* Herpetol. Rev., 10(4):119.
MYERS, C. W.
1967. The Pine Woods Snake, *Rhadinaea flavilata* (Cope). Bull. Florida St. Mus., 11(2):47–97.
MYERS, S.
1977. Geographic distribution: *Osteopilus septentrionalis.* Herpetol. Rev., 8(2): 38.
1978a. Geographic distribution: *Anolis sagrei.* Herpetol. Rev., 9(3):107–108.
1978b. Geographic distribution: *Hemidactylus turcicus.* Herpetol. Rev., 9(3): 107–108.
1979. Geographic distribution: *Hemidactylus garnoti.* Herpetol. Rev., 10(3): 102–103.
1981. Geographic distribution: *Anolis sagrei.* Herpetol. Rev., 12(1):13.
NEILL, W. T.
1957. Historical biogeography of present-day Florida. Bull. Florida St. Mus., 2(7):176–220.
OBER, L. D.
1973. Introduction of the Haitian anole, *Anolis cybotes,* in the Miami area. HISS News-Journal, 1(3):99.
ODUM, H. T. and BROWN, M. T. (EDS.)
1975. Carrying capacity for man and nature in south Florida. Center for Wetlands, Univ. Florida, Gainesville. 3 vols.
OGDEN, J. C.
1978. Status and nesting biology of the American Crocodile, *Crocodylus acutus* (Reptilia, Crocodylidae) in Florida. J. Herpetol., 12(2):183–196.

Oliver, J. A.
1950. *Anolis sagrei* in Florida. Copeia, 1950(1):55–56.
Porras, L. and Wilson, L. D.
1979. New distributional records for *Tantilla oolitica* Telford (Reptilia, Serpentes, Colubridae) from the Florida Keys. J. Herpetol., 13(2):218–220.
Pritchard, P. C. H.
1976. *Melaleuca.* Florida Natur., 49(6):7–11.
Puckette, G. and Smith, H. M.
1963. A longevity record for *Anolis equestris.* Herpetologica, 19(2):138.
Riemer, W. J.
1958. Giant toads of Florida. Quart. J. Florida Acad. Sci., 21(3):209–211.
Roberts, M. F.
1977. All about chameleons and anoles. T.F.H. Publ., Inc., Neptune, New Jersey.
Rudloe, J.
1979. Time of the Turtle. Alfred A. Knopf, New York.
Ruibal, R.
1964. An annotated checklist and key to the anoline lizards of Cuba. Bull. Mus. Comp. Zool., 130(8):473–520.
Rundquist, E. M.
1978. Rebuttal to Smith and Kohler on introduced species. Herpetol. Rev., 9(4):131–132.
Savage, J. M.
1954. Notulae herpetologicae 1–7. Trans. Kansas Acad. Sci., 57(3):326–334.
Schwartz, A.
1952. *Hyla septentrionalis* Dumeril and Bibron on the Florida mainland. Copeia, 1952(2):117–118.
1968. Geographic variation in *Anolis distichus* Cope (Lacertilia, Iguanidae) in the Bahama Islands and Hispaniola. Bull. Mus. Comp. Zool., 137(2): 255–310.
1974. *Eleutherodactylus planirostris.* Cat. Amer. Amphib. Rept.:154.1–154.4.
Schwartz, A. and Thomas, R.
1975. A check-list of West Indian amphibians and reptiles. Carnegie Mus. Natur. Hist. Spec. Publ., 1:1–216.
Smith, H. M. and Kohler, A. J.
1978. A survey of herpetological introductions in the United States and Canada. Trans. Kansas Acad. Sci., 80(1–2):1–24.
Smith, H. M. and McCauley, R. H.
1948. Another new anole from south Florida. Proc. Biol. Soc. Washington, 61: 159–166.
Smith, H. M. and Smith, R. B.
1976. Synopsis of the herpetofauna of Mexico. Volume III. Source analysis and index for Mexican reptiles. John Johnson, North Bennington, Vermont.
South Florida Regional Planning Council
1975. Dermographic analysis 1950–1990 for Broward, Dade, Martin, Palm Beach, and St. Lucie counties. South Florida Regional Planning Council.
1976. Analysis of coastal land-use for Broward, Dade, Martin, Palm Beach, and St. Lucie counties. South Florida Regional Planning Council.
Southwest Florida Regional Planning Council
1978. Land use policy plan. Fort Myers.
Steiner, T. M. and McLamb, L. T.
1982. Geographic distribution: *Hemidactylus garnoti.* Herpetol. Rev., 13(1): 25.
Stejneger, L.
1922. Two geckos new to the fauna of the United States. Copeia, (108):56.

TEBEAU, C. W.
1966. Florida's last frontier, the history of Collier County. Univ. Miami Press, Coral Gables, Florida.
1971. A history of Florida. Univ. Miami Press, Coral Gables, Florida.
THOMAS, R. A.
1974. A checklist of Texas amphibians and reptiles. Tech. Ser. Texas Parks and Wildlife Dept., (17) a–b, 1–15.
THOMPSON, R. B. (ED.)
1977. Florida statistical abstract 1977. Univ. Presses of Florida, Gainesville.
1978. Florida statistical abstract 1978. Univ. Presses of Florida, Gainesville.
TRAPIDO, H.
1947. Range extension of *Hyla septentrionalis* in Florida. Herpetologica, 3(6): 190.
U.S. FISH AND WILDLIFE SERVICE.
1978. Endangered Species technical bulletin, 3(2):1–12.
WARD, F.
1972. The imperiled Everglades. Nat. Geogr., 141(1):1–27.
WILCOX, J. R.
1979. Florida Power and Light Company and endangered species: Examples of coexistence. U.S. For. Svc. Gen. Tech. Rep. RM 65:451–454.
WYGODA, M. L. and BAIN, J. R.
1980. Geographic distribution: *Anolis sagrei*. Herpetol. Rev., 11(4):115.

APPENDIX

The following is a list of amphibians and reptiles that are native to South Florida. Common names are those recommended by Collins *et al.* (1982).

SALAMANDERS AND NEWTS

Amphiuma means	Two-toed Amphiuma
Nothophthalmus viridescens	Eastern Newt
Pseudobranchus striatus	Dwarf Siren
Siren lacertina	Greater Siren

FROGS AND TOADS

Acris gryllus	Southern Cricket Frog
Bufo quercicus	Oak Toad
Bufo terrestris	Southern Toad
Gastrophyne carolinensis	Eastern Narrowmouth Toad
Hyla cinerea	Green Treefrog
Hyla femoralis	Pine Woods Treefrog
Hyla gratiosa	Barking Treefrog
Hyla squirella	Squirrel Treefrog
Limnaoedus ocularis	Little Grass Frog
Pseudacris nigrita	Southern Chorus Frog
Rana areolata	Crawfish Frog
Rana grylio	Pig Frog
Rana sphenocephala	Southern Leopard Frog
Scaphiopus holbrookii	Eastern Spadefoot

Turtles

Chelydra serpentina	Snapping Turtle
Deirochelys reticularia	Chicken Turtle
Gopherus polyphemus	Gopher Tortoise
Kinosternon baurii	Striped Mud Turtle
Kinosternon subrubrum	Eastern Mud Turtle
Malaclemys terrapin	Diamondback Terrapin
Pseudemys floridana	Cooter
Pseudemys nelsoni	Florida Redbelly Turtle
Sternotherus odoratus	Stinkpot
Terrapene carolina	Eastern Box Turtle
Trionyx ferox	Florida Softshell

Crocodilians

Alligator mississippiensis	American Alligator
Crocodylus acutus	American Crocodile

Lizards

Anolis carolinensis	Green Anole
Anolis distichus	Bark Anole
Cnemidophorus sexlineatus	Six-lined Racerunner
Eumeces egregius	Mole Skink
Eumeces inexpectatus	Southeastern Five-lined Skink
Ophisaurus attenuatus	Slender Glass Lizard
Ophisaurus compressus	Island Glass Lizard
Ophisaurus ventralis	Eastern Glass Lizard
Sceloporus woodi	Florida Scrub Lizard
Scincella lateralis	Ground Skink
Sphaerodactylus notatus	Reef Gecko

Snakes

Agkistrodon piscivorus	Cottonmouth
Cemophora coccinea	Scarlet Snake
Coluber constrictor	Racer
Crotalus adamanteus	Eastern Diamondback Rattlesnake
Diadophis punctatus	Ringneck Snake
Drymarchon corais	Indigo Snake
Elaphe guttata	Corn Snake
Elaphe obsoleta	Rat Snake
Farancia abacura	Mud Snake
Heterodon platyrhinos	Eastern Hognose Snake
Lampropeltis getulus	Common Kingsnake
Lampropeltis triangulum	Milk Snake
Masticophis flagellum	Coachwhip

Micrurus fulvius	Eastern Coral Snake
Nerodia cyclopion	Green Water Snake
Nerodia fasciata	Southern Water Snake
Nerodia taxispilota	Brown Water Snake
Opheodrys aestivus	Rough Green Snake
Pituophis melanoleucus	Pine Snake
Regina alleni	Striped Crayfish Snake
Rhadinaea flavilata	Pine Woods Snake
Seminatrix pygaea	Black Swamp Snake
Sistrurus miliarius	Pigmy Rattlesnake
Storeria dekayi	Brown Snake
Tantilla oolitica	Rim Rock Crowned Snake
Tantilla relicta	Florida Crowned Snake
Thamnophis sauritus	Eastern Ribbon Snake
Thamnophis sirtalis	Common Garter Snake

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1. Catalogue of publications in herpetology published by the University of Kansas Museum of Natural History. By Linda Trueb. Pp. 1–15. December 1976. $0.25 postpaid.
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5. The natural history of Mexican rattlesnakes. By Barry L. Armstrong and James B. Murphy. Pp. 1–88. 14 December 1979. $6.00 postpaid.
7. A diapsid reptile from the Pennsylvanian of Kansas. By Robert R. Reisz. Pp. 1–74. 18 February 1981. $5.00 postpaid.
8. 1982 Catalog of publications of the University of Kansas Museum of Natural History. Pp. 1–28. November 1982. $1.00 postpaid or free with orders.