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**Verified non-indigenous amphibians and reptiles in Florida
from 1863 through 2010:
Outlining the invasion process and identifying invasion pathways and stages**

KENNETH L. KRYSKO¹, JOSEPH P. BURGESS², MICHAEL R. ROCHFORD³, CHRISTOPHER R. GILLETTE⁴, DANIEL CUEVA⁵, KEVIN M. ENGE⁶, LOUIS A. SOMMA⁷, JENNIFER L. STABILE⁸, DUSTIN C. SMITH⁹, JOSEPH A. WASILEWSKI¹⁰, GUY N. KIECKHEFER III³, MICHAEL C. GRANATOSKY^{1,11} & STUART V. NIELSEN¹²

¹Florida Museum of Natural History, Division of Herpetology, University of Florida, Gainesville, Florida 32611, USA
(e-mail: KLK: kenneyk@flmnh.ufl.edu)

²Florida Department of Environmental Protection, GTM NERR, Ponte Vedra, Florida 32082, USA (e-mail: Joseph.Burgess@dep.state.fl.us)

³University of Florida, Fort Lauderdale Research and Education Center, 3205 College Avenue, Fort Lauderdale, Florida 33314-7719, USA
(e-mail: MRR: mikerochford@hotmail.com, GNK: gnkieck@gmail.com)

⁴Florida International University, Department of Environmental Studies, Modesto Maidique Campus, 11200 SW 8th Street, Miami, Florida 33199, USA (e-mail: cgill002@fiu.edu)

⁵Florida International University, Department of Biological Sciences, Modesto Maidique Campus, 11200 SW 8th Street, Miami, Florida 33199, USA (e-mail: dvede001@fiu.edu)

⁶Florida Fish and Wildlife Conservation Commission, 1105 SW Williston Road, Gainesville, Florida 32601, USA
(e-mail: kevin.enge@myfwc.com)

⁷Volunteer in Herpetology, Florida Museum of Natural History, University of Florida, Gainesville, Florida 32611, USA
(e-mail: somma@ufl.edu)

⁸Central Florida Zoological Park, 3755 NW Highway 17-92, Sanford, Florida 32747, USA (e-mail: jens@centralfloridazoo.org)

⁹Zoo Miami, 12400 Southwest 152nd Street, Miami, Florida 33177, USA (e-mail: dustinmi@miamidade.gov)

¹⁰Natural Selections, 24305 SW 142th Avenue, Homestead, Florida 33032, USA (jawnatset@bellsouth.net)

¹¹Present address: Department of Evolutionary Anthropology, P.O. Box 90383, Duke University, Durham, North Carolina 27708, USA
(e-mail: michael.granatosky@duke.edu)

¹²University of Mississippi, Department of Biology, 214 Shoemaker Hall, University, Mississippi 38677, USA (e-mail: svnielse@olemiss.edu)



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KENNETH L. KRYSKO, JOSEPH P. BURGESS, MICHAEL R. ROCHFORD, CHRISTOPHER R. GILLETTE, DANIEL CUEVA, KEVIN M. ENGE, LOUIS A. SOMMA, JENNIFER L. STABILE, DUSTIN C. SMITH, JOSEPH A. WASILEWSKI, GUY N. KIECKHEFER III, MICHAEL C. GRANATOSKY & STUART V. NIELSEN

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Abstract

We follow a biological invasion model that consists of a series of five consecutive obligatory stages, concluding with stages 4a and 5 (i.e., widespread = invasive species). The State of Florida is infamous for having the most introduced (stages 2–5) amphibians and reptiles in the United States. However, there is disagreement regarding their numbers as well as identification in some cases. Unverified claims of species being introduced (stage 2), or established (stages 3–5) without evidence (i.e., a voucher specimen or photograph) are prevalent in the literature. It is crucial to provide data on all known non-indigenous herpetofaunal species via vouchers to help keep numbers of species consistent, accurately identify species, document when and where a particular species is found, and identify the invasion pathway and current invasion stage of each species. In this study, we use vouchers to confirm interceptions and introductions of all known non-indigenous amphibians and reptiles in Florida from 1863 through 2010, provide a list of these species along with their invasion pathways and current ecological status (i.e., invasion stage), and provide a species account for each newly confirmed species. We include species that were previously reported in the literature but lacking an associated voucher

and provide greater details on previously reported species and those species whose invasion stage has been upgraded to established (stages 3–5). Based on nearly two decades of field work along with examination of museum records and literature, we confirm three intercepted and 137 introduced amphibian and reptile taxa in Florida. Of these, 56 are established (i.e., reproducing; stages 3–5), including three frogs, four turtles, one crocodylian, 43 lizards, and five snakes. Of 149 total independent introduction pathways (i.e., including a different pathway one time only for each taxon) for the 140 total non-indigenous taxa above, two (1.34%) are related to the biological control pathway, four (2.68%) to the zoo pathway, 18 (12.08%) to the cargo pathway, and 125 (83.89%) to the pet trade pathway. Florida now ranks as having the largest number of established non-indigenous herpetofaunal species in the entire world. Despite current state laws that make it illegal to release any non-indigenous animal in Florida without first obtaining a permit from the Florida Fish and Wildlife Conservation Commission, enforcement is difficult, and no person has ever been prosecuted for the establishment of a non-indigenous animal species in Florida. Because current state and federal laws have not been effective in curtailing the ever-increasing number of illegal introductions, laws need to be modified and made enforceable. At the very least, those responsible for introductions should be held accountable for compensation to clean up (= extermination) of those species for which they are responsible. Lastly, we strongly support the creation of an Early Detection and Rapid Response program to quickly identify newly found introduced species for eradication attempts. This paper will also serve as a baseline to document future introductions.

Key words: alien, checklist, crocodylian, exotic, frog, herpetology, lizard, non-native, salamander, snake, turtle

“That which is lost is the beauty inherent in the biological systems and relationships evolved under unique historical regimes of migration, competition, and evolutionary accommodation. These unique histories have led to the evolutionary development of unique floras and faunas in different parts of the world. These evolved biotas include species, each with a unique combination of adaptive features allowing it to survive in its own particular slice of the world; communities of coevolved and co-accommodating species creating geographically unique assemblages of life forms; and the ecosystems whose mix of unique communities, climatic regimes, and topography impart to landscapes their specific distinctiveness and appeal. I suggest that the distinctive co-evolved, unique beauty of each of these systems is besmirched by the introduction of alien species – much as a beautiful beach or coastline may be impaired by an oil spill. Or perhaps more aptly, the facile pollution of these self-generated biotas by human introductions is equivalent to splattering the canvases in the Louvre with day-glo paint: the structural integrity of the canvases may not be marred, the added colors may be beautiful, but the aesthetic integrity of the artworks is thoroughly violated. The difference, of course, is that the impact of an oil spill lasts for mere years, vandalization of a painting may be rectified by careful restoration, but alien invasions are most usually irreversible and irreparable.”

Fred Kraus (2009: 13)

Introduction

Introduced species are second in negative effects only to human-mediated effects on native species, habitats, and whole ecosystems (Simberloff *et al.* 1997; Wilcove *et al.* 1998; Parker *et al.* 1999; Pimentel *et al.* 2000, 2005; Kraus 2009). Many introduced species not only cause harm to the environment, but also to the economy and human health (Executive Order 13112, Invasive Species Advisory Committee 2006; Kraus 2009). Invasion ecologists study the processes by which organisms are transported and become introduced to new areas where they are not native. Below we illustrate one model of the invasion process as a reference guide, although other similar frameworks exist (e.g., Williamson & Fitter 1996; Kolar & Lodge 2002; Fletcher 2005; Hill 2008). Colautti and MacIsaac (2004) break down the invasion process into a series of five consecutive obligatory stages, concluding with stages 4a and 5 (i.e., *widespread = invasive species*; although these authors deter using the term *invasive species* [R. Colautti personal communication]).

- Stage 0 = Potential invader begins as a resident in its native or a donor region.
- Stage 1 = Potential invader is transported to a new area.
- Stage 2 = Potential invader survives transport, escapes or is released (i.e., becomes introduced), and is thus non-indigenous to the new area.
- Stage 3 = Non-indigenous species survives and establishes (reproduces) in the new suitable environment but remains uncommon and localized.