



The Environmental Foundation of Jamaica
in association with
Jamaica Conservation and Development Trust
present

The 7th Annual EFJ Public Lecture

On the Brink of EXTINCTION:

Saving Jamaica's Vanishing Species



Dr. Byron Wilson, Senior Lecturer, Department of Life Sciences,
University of the West Indies, Mona

October 20, 2011, 5:30pm



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FOREWORD

The Environmental Foundation of Jamaica (EFJ) is very pleased to welcome you to our 7th Annual Public Lecture.

The Lecture this year is being organized in partnership with our member and long standing partners at the Jamaica Conservation and Development Trust (JCDDT). JCDDT has been a major player not only in Protected Areas and Management of the Blue and John Crow Mountain National Park, but also in the area of public awareness and education with features such as the National Green Expo held every other year.

Like all our work over the last 18 years, we have balanced the Public Lectures between our two major areas of focus – Child Development and Environmental Management.

This year, our environmental lecture will focus on issues of biodiversity and human impact on ecological habitats. Our lecturer, Dr. Byron Wilson is a Senior Lecturer in the University of the West Indies. He is an expert in conservation biology and has dedicated his research to the ecology and conservation of the critically endangered Jamaican Iguana and other rare endemic reptile species.

In addition to Dr. Wilson's work, the EFJ has partnered with Government, Researchers and Conservationists to study and record critical information and data on Endemic and Endangered Species across Jamaica, including the establishment of the UWI/EFJ Biodiversity Centre in Port Royal, the Virtual Herbarium and the publication of the "Endemic Trees of Jamaica" book. The Foundation is committed to improving and promoting information and knowledge on these Jamaican treasures for our scholars, our students, our history, and our people.

We hope that the information from this lecture teaches you at least one new thing about some of the animals of Jamaica, that it renews your appreciation for them and that you also learn what you – and the country - can do about those "On the Brink of Extinction" and our role in "Saving Jamaica's Vanishing Species".

ABOUT THE ENVIRONMENTAL FOUNDATION OF JAMAICA AND ITS ENVIRONMENT PROGRAMME

The Environmental Foundation of Jamaica (EFJ) is a grant making institution established to provide funding to Non-Governmental Organisations (NGOs) involved in the management and sustainable use of Jamaica's natural resources, and in issues of child development. Established in 1993, the EFJ is an independent Foundation, which uses the proceeds from a creative debt-swap arrangement to promote sustainable development in Jamaica.

Since its inception, the priorities of the EFJ's Environment Programme have been on the following critical issues:

- Watershed & Coastal Zone Management
- Biodiversity Conservation
- Waste and Water Management
- Alternative Energy
- Climate Change

The Foundation has worked with a range of institutions including Environmental NGOs, Community-Based Organisations (Churches, Farmers, Fishermen), National Civil Society Groups and Academia. As silent partners with many local, community-level groups and other types of NGOs across Jamaica, the EFJ has been able to assist with informal and formal education on environmental issues, change in behaviour to environmentally-friendly technologies and habits, academic research on species and their habitats and initiatives encouraging sustainable agriculture and solid waste recycling.

Some of our most recent successes include the following projects:

- Jeffery Town Farmers Association: is a community-based organisation which received support for a hybrid wind and solar system to produce clean, cheaper power for their community centre. The centre houses a multimedia centre and community radio station JET FM 88.7. The

system produces approximately 80% of the energy needs of the JFTA Centre. With this community based hybrid system, JFTA has realised savings of approximately 45% per month.

- Biodiversity Education: has been encouraged through a number of EFJ grant awards targeting the need for general and scientific knowledge on Jamaica's biodiversity. *Learning in and Beyond the Classroom- Biodiversity Initiatives in Teacher Education* produced by Jamaica Environment Trust (JET)/Joint Board of Teacher Education (JBTE); *Endemic Trees of Jamaica*, a publication produced by Natural History Society in conjunction with the Institute of Jamaica (IOJ); and University of the West Indies' (UWI) *Virtual Herbarium* housing over 1600 species of flora in Jamaica from collections at UWI and IOJ.
- Protected Areas Management: support to fish sanctuaries managed by Caribbean Coastal Area Management Foundation Ltd. (CCAM) and the Oracabessa Foundation has facilitated the completion of Fish Sanctuary Management Plans for 4 fish sanctuaries. Important features of these plans include engaging in collaborative discussions with the fishermen and other regular users of the fish sanctuaries, conducting baseline assessments as well as developing strategies for public education and monitoring and enforcement.
- Reforestation and Sustainable Agricultural Practices: Mocho Development Committee and Northern Caribbean University (NCU) in collaboration with the College of Agriculture Science and Education have over the past year implemented reforestation projects in sensitive areas while at the same time encouraging sustainable agriculture and land management practices. Mocho farmers have rehabilitated 40 hectares of bauxite mined/reclaimed land and NCU has reforested 45 hectares of land in the Swift River Watershed.

The EFJ looks forward to the continuation of its environment programme in partnership with NGOs/CBOs and other development partners, toward the conservation and management of Jamaica's natural resources and environment as we pursue our vision of **"Preserving The FutureToday!"**.

ABOUT THE AUTHOR



Byron S. Wilson received his undergraduate degree in Zoology from the University of California, Berkeley, and his PhD in Zoology from the University of Washington (USA). His thesis research focused on latitudinal variation in the ecology and physiology of a widespread lizard, and involved extensive field work in the deserts of California, Nevada, Oregon, and Washington. Upon completing his doctoral dissertation Wilson focused on endangered species conservation projects, including postdoctoral stints at two University of California campuses (UCLA and UCSD) and consultancy work on threatened species, including reptiles, birds, and mammals.

Dr. Wilson moved to Jamaica in 1997 to work on the Jamaican iguana recovery project, and after several years as a Research Fellow at The University of the West Indies, Mona, was hired as a Lecturer in 2001, and appointed as a Senior Lecturer in Conservation Biology in 2007. His current research focuses on the conservation of the island's threatened endemic species and natural habitats. Primary projects include the Jamaican iguana recovery effort, the ecology of the American crocodile, the taxonomic and conservation status of the endemic Jamaican slider turtle, the status of the island's endemic amphibian species, and long-term monitoring of dry forest fauna in the context of a predator control experiment in the Hellshire Hills. Additional projects include a MacArthur Foundation-funded project focusing on the ecology and conservation of the Cockpit Country and Black River Lower Morass, with Lead Investigator Dr. Kurt McLaren.

ACKNOWLEDGMENTS

Much of this text is based on two recent papers (Wilson 2011, and Wilson et al. 2011), published in a 2-volume book series on the conservation of insular Caribbean amphibians and reptiles (Hailey et al. 2011). I am especially indebted to the senior editor of that effort, Dr. Adrian Hailey of the University of the West Indies, St. Augustine; he provided me with an opportunity to put my thoughts on conservation in Jamaica to paper. I also thank the co-authors of the Wilson et al. paper, as well as reviewers and colleagues who contributed ideas, field assistance, or other forms of support. In particular, I thank Professor Simon Mitchell for help on both of the book contributions, and for assistance with preparing this talk.

Finally, I thank Environmental Foundation Jamaica for making this information available to a wider, perhaps more important audience, and for providing an opportunity for me to explore other aspects of Jamaica's history of biodiversity loss.

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The Lecture





INTRODUCTION

‘Biodiversity Hotspots’ are regions of the world that contain a large number of endemic species that are threatened with extinction. Endemic species are those found only in particular places, such as on particular islands – like Jamaica. The Caribbean is one of 25 recognized global hotspots, and Jamaica is regarded as a ‘hotspot within a hotspot’. Indeed, the ‘Land of Wood and Water’ boasts an impressive list of endemic species – unique forms of life found only in Jamaica -- and unfortunately, many of those species are at high risk of extinction.

This presentation is organized into roughly six parts, with some intended coherence that may or may not be evident to the reader. We will first discuss a few of Jamaica’s more notable ‘natural extinctions’ and distinguish between those ‘old time’ extinctions and extinctions of the more recent, man-made variety. Second, we will discuss the current human-mediated threats to Jamaica’s environment and to the island’s rich collection of unique plant and animal species. Third, we will examine some comparatively recent Jamaican extinctions, particularly in light of the role we humans have played in these tragic losses of global diversity. Fourth, we will consider some of the species that are now currently threatened with extinction, and whose future will depend on more responsible stewardship of the island’s natural environment.

This is a hugely unhappy saga that should serve as a warning: if so many Jamaican species have recently been driven to extinction or are now threatened, it is a sobering reminder that something is wrong with the island’s natural environment. But it is not too late to reverse this negative trend, and rescue some unique Jamaican species from what otherwise appears to be certain extinction. Appropriately then, we will move on to discussing some current conservation activities and priorities before ending our discussion by highlighting the hope and possibilities that remain.



Crocodile



PART I

A Comment on Jamaica's Ancient and Biological Histories

To understand the history of life on Jamaica, we must first briefly review the history of the island itself. Jamaica's geological history goes back over 100 million years, when it was part of a chain of volcanic islands, much like what we see in the present day Lesser Antilles. Fossil remains from this period consist primarily of ancient marine organisms, mostly invertebrates (animals without backbones). Terrestrial fossil remains, particularly of vertebrates (animals with backbones), have been very rare.

But two ancient fossil vertebrates are of special note. First, Jamaica had its own rhinoceros. This was a relatively small species that roamed the island some 45 Millennia Ago (Ma), which translates into 45 million years from present. Another important find was an extinct manatee that also inhabited the island around 45 Ma. The manatee fossil is of great evolutionary interest, because it is intermediate between present day, entirely aquatic manatees, and the more primitive land-living form from which other manatees evolved. In other words, this is the sort of 'missing link' that Darwin correctly predicted would someday be found. After the reign of the rhinoceros and manatee, Jamaica slipped beneath the sea for around 30 million years...

Modern Jamaica is believed to have re-emerged from the sea some 14 Ma, making it considerably younger than the other Greater Antillean islands. Jamaica's biota (its plants and animals) is therefore the product of a shorter history of colonization and subsequent evolutionary diversification than are those of the other Greater Antillean islands. Nevertheless, Jamaica boasts a highly diverse and endemic biota — owing in part to its wide altitudinal gradient (sea level to 2256 m), and diversity of habitats. For example, Jamaica is ranked 5th in the world in terms of endemic plant diversity on islands (Davis et al., 1997), supports the highest density of endemic bird species found on any island in the West Indies, and harbours a highly endemic land snail fauna that is as diverse as any in the world (Rosenberg and Muratov, 2006).



Natural Extinctions

The extinction of the rhinoceros and the manatee are what we refer to as natural extinctions, meaning that they were not a result of human interference, but rather, resulted from long-term changes in climate, or in other natural processes. Just as the dinosaurs went extinct, so too did a myriad of other species – long before us humans entered the scene. But past rates of extinction were, on the whole, rather slow, so that evolution could generate new species to replace those that had been lost. Experts now estimate that present day extinction rates are somewhere between 10 and 100 times greater than so-called ‘background’ (i.e., natural) extinction rates. This dramatic acceleration in extinction rates is due solely to man’s mismanagement and mistreatment of Earth’s environment.

PART II

Recent and Current Threats from the Human Species

The factors endangering Jamaican species are largely obvious and typical of those that impact other island faunas. Historically, some species were negatively impacted by early (i.e., pre-Columbian) settlers such as the Tainos (Case et al., 1992).

Without exception, these were large, edible, and terrestrial species such as lizards of the genus *Cyclura*. A more substantial wave of extirpations and extinctions was to accompany European colonization – the dawn of wholesale environmental destruction. A combination of large-scale habitat conversion for agriculture and human settlements, and the intentional or unintentional introduction of mammals such as rats, cats, and mongooses, has resulted in a wave of extirpations and extinctions over the past 500 years (Case and Bolger, 1991; Corke, 1992; Henderson, 1992).

Habitat Loss and the Human Population Problem: Too Many People and Too Little Land

The ultimate cause of the current global extinction crisis is the explosive growth of the human population, and this is nowhere more obvious than



in the West Indies. For example, the human population in the British Virgin Islands has doubled in the last three decades, and is expected to double again in the next 35 years (Perry and Gerber, 2011). Barbados is ranked as one of the top 10 most densely populated sovereign states and, not surprisingly, has lost essentially all of its primary forests. The habitat loss that necessarily attends population expansion has been an overriding threat factor in the West Indies, and Jamaica is no exception.

In addition to the direct loss of individuals, the range and population size contraction resulting from habitat reduction will render already threatened species at even greater risk of future extinction from other causes. The loss of habitat will also render many potential reintroduction programmes unrealistic, because sufficient habitat will not be available to support re-introduced populations (e.g., the Puerto Rican toad on Anegada; Perry and Gerber, 2011). In short, habitat loss is the single greatest threat to the persistence of plant and animal life on earth, and nowhere is this problem more acute than on islands such as Jamaica (Hedges, 2006; Wilson et al., 2006).

Once almost covered by dry, moist, and wet tropical forests, few lowland habitats on Jamaica retain any semblance of naturalness, and high-quality primary forest probably covers less than 5% of the island. With the possible exception of a few remote forested areas located on steep slopes, Jamaica has retained no truly pristine habitat. Large scale land conversion associated with agriculture (primarily sugar cane), together with timber extraction (for lumber and fuel) decimated the island's lowland forests in the centuries following European colonization. Subsequent population expansion and the attending explosion of commercial, residential, and urban development further contracted the island's natural habitats. Today, primary forest habitat is largely restricted to rugged inland areas that are not accessible by road. Nevertheless, those areas are under assault from small-scale



Crocodile nest



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agriculture, bauxite mining, limestone quarrying, road construction, and squatting (i.e., illegal settlements). Coastal habitats, including what few undeveloped white sand beaches remain, are at risk of being extirpated by the latest economic boom: tourism development.

Invasive Species

Humans have introduced, either intentionally or accidentally, a large number of plant and animal species not native to the island, and many of these invaders have become problematic for indigenous wildlife species. On land, the impact of introduced mammalian predators has been the most conspicuous invasive species issue, and this attention is no doubt warranted (Case and Bolger, 1991). For example, mammalian predators such as the cat and mongoose (*Herpestes auropunctatus*) have been implicated in the extinction or near extinction of at least four reptile and two bird species in Jamaica.

Dietary studies in the Hellshire Hills have confirmed that the mongoose is a highly efficient predator of diurnal ground reptiles; the remains of 14 individual lizards were found in the stomach of a single mongoose (Lewis, pers. comm.; and see Lewis, 2002). Cats represent a more insidious threat, and are known to consume various endemic species, including the Critically Endangered Jamaican iguana and the more



Blue-tailed Galliwasp

recently “re-discovered” blue-tailed galliwasp (*Celestus duquesneyi*). For birds, domestic and feral cats rank second only to habitat loss as the leading cause of endangerment and extinction. Dogs, first brought to Jamaica by the Tainos, are the only predator capable of killing adult iguanas, and they also represent a threat to nesting sea turtles and their nests.

Introduced herbivores such as goats have had a marked effect on the vegetation of tropical islands, although this appears to be important for Jamaica only on the Goat Islands — two small offshore cays located west of the Hellshire Hills. Goats also exert indirect effects on animal



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populations through the alteration of habitat structure and prey bases (Henderson, 1992; Tolson and Henderson, 2011). Wild pigs consume diverse animal species, represent a severe threat to reptile eggs (e.g., *Cyclura* species, sea turtles), endanger native plants and plant communities, and, like goats, indirectly impact other (native) species by altering habitats and prey bases (Alberts, 2000; Tolson and Henderson, 2011).

European rodents (*Rattus* spp. and *Mus musculus*) are present in both disturbed and natural areas, but their impact on amphibian and reptile populations in Jamaica is unknown. *Rattus norvegicus* is probably a threat to diverse taxa at, below, or near ground level; *R. rattus*, being more arboreal, is also a threat to bromeliad-inhabiting species (Hedges and Diaz, 2011).

Aside from mammals, a number of other vertebrates have also become highly invasive on the island. The cane toad (*Bufo marinus*), known locally as 'bullfrog', was introduced to Jamaica in 1855 (Lewis, 1949) to control pests on sugar cane plantations, and now occurs throughout the island at lower and mid-elevations. Ranked among the world's 100 worst invasive species (Lowe et al., 2000), *B. marinus* almost certainly impacts native species through predation and competition, and recent evidence indicates that snakes such as the endemic Jamaican boa (*Epicrates subflavus*) can succumb to bufotoxin (a poison exuded by the toads) during predation attempts (Wilson et al., 2010). Another consideration is the possible role of *B. marinus* as a vector for the spread of diseases that could negatively



Setting a pig snare in Hellshire Swamp



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impact Jamaica's native amphibians (cf. Diaz et al., 2007; Zupanovic et al., 1998).

The American Bullfrog (*Rana catesbeiana*) was introduced to Jamaica in 1967 to initiate a frog legs industry (Mahon and Aiken, 1977), though reports of earlier introductions exist (Crombie, 1999).

From its reported introduction site in the Black River area of St. Elizabeth, the species has spread at least as far as the parishes of St. Catherine and St. Mary, probably facilitated by



Birds at Hellshire swamp

incidental transfer with aquaculture products such as fingerling Tilapia (*Oreochromis* spp.). *Rana catesbeiana* is also listed among the world's 100 worst invasive species (Lowe et al., 2000), and is assumed to negatively impact Jamaica's native fauna, through predation and competition. This species is also known to carry the fungal pathogen *Batrachochytrium dendrobatidis* (Bd) (e.g., Schloegel et al., 2009), and may well have been the original source of suspected introduction to Jamaica; *R. catesbeiana* is also a known carrier of ranavirus, another pathogen that targets frogs (e.g., Schloegel et al., 2009).

Of course, invasive species other than vertebrates have also negatively influenced native Jamaican plant and animal species. For example, invasive invertebrates such as the fire ant (*Solenopsis invicta*) are known to affect both invertebrate and vertebrate populations (e.g., Allen et al., 1997), though their impact in the region has been largely unstudied. And it is not just invasive animals that can adversely affect native species; invasive plants, like invasive herbivores, can also alter habitats and prey bases. The impact of invasive plants on native West Indian species has not gone unnoticed, but has received little research or conservation attention. Many habitats in the West Indies are now dominated by non-native plant species, and this has obviously affected the distribution and abundance of native species and populations.



Yet the influence of invasive species is by no means limited to terrestrial environments. Jamaica's waters, both salt and fresh, are now overrun with invasive species. Most of Jamaica's fresh water systems are now dominated by alien invasive species, and especially conspicuous are species that were imported for the aquaculture trade. More recently, the Indo-Pacific lionfish has invaded the Caribbean Sea, and has now set up shop in Jamaica's territorial waters. It is presently uncertain how devastating this invasion will prove to be for Jamaica's economy; what is certain is that no marine species has ever been successfully eradicated, so the lionfish appears to be here for good. Moreover, control efforts aimed at mitigating negative impacts are likely to be only minimally effective. Indeed, the lionfish may prove to be the biggest invasive species catastrophe ever to impact the island's environment and economy.

Unfortunately, future introductions would appear to be inevitable. Several avenues in particular, seem likely to result in the eventual introduction of additional species that could become problematic for the island's naturally occurring species. A recent proliferation of private 'wildlife attractions' and pet stores could lead to the introduction of species that could compete with, depredate, hybridize with, or transfer diseases to native species. Given the vulnerability of island plants and animals to the threat of invasive species, these "backyard" menageries and the trade in exotic animal species should both be banned. Illegal importation and the accidental introduction of organisms through international trade will be more difficult to curtail.

To be sure, the continued illegal importation of mammals in particular, represents a significant threat to public health. One excellent example is the continued smuggling of dogs such as American Pit Bull Terriers (and



Hatchling Jamaican Iguana - the only iguana that should be on the island

derivative 'vicious' breeds) from North and Central America. These animals are a threat to both humans and wildlife, and not just because they can be vicious. In particular, the potential for introducing rabies to Jamaica should be of national security concern – and a smuggled dog is



among the more likely avenues through which this devastating disease could reach Jamaica.

Other Direct Human Impacts: Over-exploitation

Human over-exploitation of edible species has been a major factor in the West Indies, but is less so today, primarily because a number of sensitive taxa have already been driven to extinction. Overall, sea turtle populations in the West Indies have been greatly reduced in size, primarily as a result of over-exploitation; and this, in spite of the fact that extinction risk resulting from unsustainable harvesting was recognized hundreds of years ago (e.g., the Act of Bermuda Assembly 1620).

On Jamaica, a number of larger species were exploited by the island's pre-Columbian inhabitants - first by the Jamaican Redware culture, and later by the Tainos (Atkinson, 2006; Allsworth-Jones, 2008; Rampersad, 2009). In addition to sea turtles, the endemic freshwater slider turtle, the endemic iguana, and crocodiles, the Tainos apparently consumed snakes and medium-sized lizards (Atkinson, 2006; Carlson, pers. comm.). Although the history of Amerindian occupation of Jamaica was comparatively brief, and population densities may have been only modest, the island's early inhabitants clearly over-exploited marine resources (Hardt, 2009; and see Blick, 2007).

But it was commercial exploitation following European colonization that would devastate populations of the island's harvestable species. For example, a major local and export trade in sea turtles decimated nesting populations during the 17th and 18th centuries (Sutton et al., 2008). Manatees were called 'sea cows' for a reason, and it wasn't because they were milked; rather, they were slaughtered for their meat, and a combination of subsistence and commercial exploitation resulted in the near extermination of the species from Jamaica.

Crocodiles were also over-exploited (probably in part for food) during the colonial period, and extensive hunting for skins and recreation proceeded into the mid 1900's. Protective legislation and export restrictions all but eliminated commercial exploitation by the 1970's. However, recent reports and evidence (pers. obs.) indicate that the illegal harvest and consumption of crocodile meat has emerged as a crisis-level threat to remaining



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populations. The Jamaican iguana supplied a local specialty market demand up until the mid 1600's, but loss of habitat and predation by non-native mammals probably played a much greater role in the population reductions and extirpations of this species (Vogel et al., 1996). And, whereas iguanas are consumed enthusiastically on other West Indian islands, the notion of eating a lizard would repulse most contemporary Jamaicans.

A new and disturbing threat to a number of Jamaica's threatened species has emerged in the form of recent Chinese immigrants who reportedly are purchasing threatened reptile species for consumption. Reliably reported incidents include: offers extended to locals to collect the endemic slider turtle, the endemic Jamaican boa, and the American crocodile (multiple reports); the theft of captive Jamaican boas and the edible parts of a crocodile from a nature facility, reportedly for culinary purposes; Chinese construction workers purchasing crocodile meat; recent Chinese immigrants purchasing crocodile eggs; and Chinese shop owners purchasing illegally killed boas and slider turtles (S. Koenig, pers. comm.). The recent construction of a large, new Chinese Embassy and the expansion of Chinese investment (and associated immigration) are therefore worrisome conservation indicators; the potential for an illegal harvest of threatened wildlife species to meet an ethnic Chinese market demand is a legitimate conservation concern.

Another Direct Human Impact: Persecution

To say that modern Jamaicans are not a particularly amphibian or reptile-friendly people would be a gross understatement — in spite of the absence of venomous species on the island, and the obvious economic and human health benefits provided by these unjustly maligned creatures. Crocodiles, because of their real or perceived threat to human life, or to pets and livestock, are also killed, and this trend has increased as humans continue to intrude on the crocodile's habitat (e.g., Portmore). Yet crocodiles play a critical ecological role in helping to maintain the cleanliness and integrity of their wetland habitats.

Lizards, particularly *Celestus*, are regarded as dangerous, and even 'tree lizards' (Genus *Anolis*) can be the subjects of fear-generated persecution. However, owing to their selection of household habitats, it is geckos such



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as *Aristelliger praesignis*, and the introduced *Hemidactylus*, that are the most frequent victims. Local pest control companies even advertise their ability to target these “pests” — especially the dreaded *Aristelliger*, known locally as the “croaker”, or “croaking lizard”. Given the harmless nature of all Jamaican snakes and lizards, this is nonsensical, because these species provide free pest control services and are of great benefit to both the Jamaican economy and public health. For example, frogs and lizards rid the island of agricultural pests and disease vectors such as mosquitoes, and snakes such as the endemic boa consume rats, which of course carry diseases that can be fatal to humans (e.g., leptospirosis).

Environmental Pollution

Pollutants (e.g., metals, pesticides, herbicides, nitrates, and phosphates) also impact plant and animal populations through both direct and indirect pathways (Gibbons et al., 2000). However, studies addressing the impacts of pollutants on West Indian species, and on tropical faunas in general, have been rare. But the often lax laws and weak enforcement typical of many developing island states suggest that the impact of environmental pollutants should rank as a high conservation priority in the region (Gibbons et al., 2000). The West Indies has a long history of extensive plantation agriculture, with intensive pesticide use on crops such as sugar cane and bananas, even up to modern times. In this regard Jamaica is typical. But in terms of runaway, unregulated tourism development, with consequent near shore pollution of marine habitats, Jamaica may, unfortunately, be exceptional.

Disease and Parasitism

Disease and parasitism have recently emerged as major factors implicated in the extirpation of populations and the extinction of species, particularly amphibians.

And, while it is often difficult to find the proverbial “smoking gun,” the fungal parasite *Batrachochytrium dendrobatidis* appears to have been responsible for a number of amphibian extinctions, and is suspected to have been responsible for many additional extinctions and “enigmatic declines”



in the neotropics, (Young et al., 2004), including at least one on Jamaica (Holmes et al., unpublished data). Declines attributable to diseases such as chytridiomycosis are especially problematic because they can apparently occur in otherwise pristine habitats (e.g., Lips, 1999), and because there are currently no preventative or curative options available. As a consequence, the only hope for saving many species may be captive management (Stuart et al., 2004) – an option that has already been discussed for Jamaica. The only documented example of a disease seriously affecting a West Indian reptile is viral fibropapilloma infection in green sea turtles (Gamache & Horrocks, 1991; Eliazar et al., 2000).

Global Climate Change

That increased emissions of so-called “greenhouse gases” are altering the earth’s climate is no longer a controversial hypothesis. Scientists now agree that the earth is undergoing rapid human-induced climate changes that are already having detrimental consequences for the planet’s biodiversity. By altering both temperature and precipitation regimes, global climate change will alter habitats such that many areas will no longer be capable of sustaining the species they now support. And while some currently unsuitable habitats may become inhabitable due to altered conditions, the generally poor dispersal abilities of most species will probably prevent them from colonizing those areas; hence, many species will be dangerously susceptible to climate induced changes to habitat (Gibbons et al., 2000).

Other consequences of climate change will be felt at both the species and community levels. For example, species that have temperature-dependent sex determination may suffer alterations in sex ratio that could have profound implications for population viability (e.g., sea turtles, crocodilians; Gibbons et al., 2000). The spectre of rising sea levels is of major concern. Critical coastal habitats, such as sea turtle and crocodile nesting areas, may be lost to rising sea levels. Even heat-loving lizards appear to be vulnerable to population loss associated with climate change (Sinervo et al., 2010), so essentially the entire biota will be (or is being) negatively impacted by the current global warming trend. And needless to say, the increased frequency and intensity of tropical storms appears to be a reality we are already experiencing.



Additive and Synergistic Effects

Often, population declines and extirpations are attributable to multiple causes, acting either additively or synergistically. For example, habitat loss reduces population size, and therefore exposes populations to greater risk from other factors, such as stochastic events, and the impact of invasive predators. Synergistic effects have been strongly implicated in several sudden frog extinctions; for example, the influence of global climate change appears to have heightened vulnerability to disease and resulted in the alarmingly rapid extinction of several anuran species in the neotropics (Pounds et al., 1999; Kiesecker et al., 2001; Burrowes et al., 2004).

PART III

Subfossils and 'Semi-Recent' Extinctions

Another group of extinct Jamaican animals fall into the category of 'semi-recent', and these disappearances could be natural, or could be due to man's early influence on the island. These are species for which subfossil evidence confirms their prior existence, but tells us little else. Because the creation of fossils (the replacement of organic matter with minerals) varies depending on the environment, mineralization can be so slow that a given subfossil could be anywhere from several hundred to many thousands of years old. When the ages of fossil remains are known, it can greatly inform speculation on the time or source of extinction.

Jamaican Monkey (*Xenothrix mcgregori*)

Jamaica, like Cuba and Hispaniola, previously harboured an endemic monkey species. All three species are now extinct. Radiocarbon dating indicates that the Jamaican monkey persisted up until ~2000 years ago. Given that anatomical analyses of subfossil remains suggest that the species was slow moving, and because its reign overlapped that of the island's early human inhabitants (e.g., the Tainos), it is certainly conceivable that the monkey was driven to extinction through a combination of over-



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hunting, and deaths caused by the virulent non-human predator they introduced to the island -- dogs.

Most intriguing is the possibility that monkeys persisted on the island up until the time of European colonization. This conjecture is based on two pieces of evidence. First, reports of early explorers made mention of monkeys, so anecdotal accounts exist from the time of Columbus' voyages. Second, the juxtaposition of monkey and European rat bones in at least one cave deposit suggest that the two species may have co-existed, and that could only have occurred subsequent to the arrival of Europeans. All we know for sure is that Jamaica could boast its own endemic monkey up until relatively recent times...but the species has now been relegated to the extinct bin, perhaps at the hands of man.

Giant Hutias (Aluterodon, Clidomys, and Xaymaca)

Subfossil remains have also been found for three genera (forms) of giant hutia. Unfortunately, these remains have not been dated, but are thought to be in the range of 100,000 to 200,000 years old. It therefore cannot be ruled out that these large rodents overlapped with and were hunted by the early Amerindians. The pattern of relatively large edible species disappearing first, is a common pattern in the extinction of island vertebrates. For now, there is much to learn about these and other species that once inhabited Jamaica. For example, future Amerindian excavations might provide evidence of whether these extinct hutias were an item on the early Jamaican's menu.

Flightless Ibis (Xenicibis xympthecus)

Flightlessness is a common feature of island birds, particularly larger species that lack natural predators. But the arrival of human predators and their associated predatory species (e.g., cats and dogs) can bring a quick end to such evolutionarily naive and flightless species. For example, some experts estimate that up to 2000 endemic birds were hunted to extinction by early Polynesians. The Jamaican flightless ibis may have suffered a similar fate. Notably, the endemic ibis was unique among vertebrates, in that it used its wings as clubs to fight rivals or other enemies. But this unique weaponry would have been impotent against human predators or dogs.



Jamaican Giant 'Croaking Lizard' (*Aristelliger titan*)

This giant cousin of the present-day 'croaking lizard' would no doubt have inspired great fear, if indeed its existence overlapped with that of modern Jamaicans. But its large size would have predisposed it to extinction by humans (perhaps for food) or introduced predators, making its disappearance due to human agency a likelihood. Known from subfossil evidence dated to around 700 years ago, the exact date of *A. titan*'s extinction is obviously unknown. For now, and in the absence of additional data (e.g., specimens and radiocarbon dates), the history of this species, and the cause of its demise, will remain mysteries.

Jamaican Curly-tailed Lizard (*Leiocephalus jamaicensis*)

This species is known from subfossils dated to around 700 years ago. Expert opinion is that the species was probably around at the time of European colonization, and its disappearance therefore represents a recent, human-mediated extinction.

Other Semi-Recent Losses from the Jamaican Fauna

Subfossil remains also attest to the prior existence of other species, some of which were not (or have not) been properly documented by science. In other words, we have undoubtedly lost some species that we will never know much or anything about. This includes a large hawk, a form of the Burrowing Owl, a possible new species of Caracara (a large hawk-like bird), an un-described Cavimorph rodent, and at least one other large lizard. Of course, new discoveries continue to come in, so the list of recently extinct species is likely to grow.

Very Recent (Human-mediated) Extinctions: But How Do We Know That Something is Extinct?

Before discussing 'recent extinctions' it is useful to visit the formal criteria for concluding that a species has been lost. Briefly, for a species to be considered forever gone, extensive survey efforts must be conducted over



the entire potential range of the species. Those surveys must be conducted in appropriate habitats, during appropriate seasons, and during the time of day (or night) that the species is active. This is a tall order, especially when considering shy or cryptic (= camouflaged) species that may be difficult to find even when they are relatively abundant. In other words, determining extinction is no simple matter, and question marks often linger. For Jamaica, a suite of species are definitive question marks, as their status is decidedly uncertain. And therein lies the hope: some 'missing' species may ultimately prove to be with us. It has happened twice in the past few decades (Jamaican iguana, Blue-tailed Galliwasp), and it could certainly happen again.

Very Recently Extinct Jamaican Species

Jamaican Rice Rat (*Oryzomys antillarum*)

This endemic rodent persisted up until the late 19th century, with the last known live specimen being collected in 1877. This extinction occurred shortly after the introduction of the Indian mongoose, but its demise may have been attributable to other factors. Sadly, the disappearance of the endemic Rice Rat reduced the island's native land mammal fauna to a single present-day species -- the Jamaican hutia.

Jamaican Pauraque (*Siphonorhis americana*)

Related to the night hawks, this endemic bird apparently disappeared shortly after the introduction of the mongoose in 1872. Being a ground nester, the Pauraque would have been easy fodder for the mongoose and for cats as well, so its disappearance is most likely attributable to these unnatural predators. On the other hand, some still hold out hope that the species persists, possibly in the isolated forests of the Hellshire Hills. But this is optimism of a high order; in all likelihood the species has been lost.

Jamaican Petrel (*Pterodroma caribbaea*)

Like the Pauraque, the endemic Jamaican Petrel also disappeared shortly after the introduction of the mongoose, around 130 years ago. Also like the Pauraque, this species is officially listed as Critically Endangered by



the International Union for Conservation of Nature (IUCN), but there appears to be diminishing hope that it will be 're-discovered'.

Jamaican Rail (or Uniform Crane) (Amaurolimnas concolor concolor)

This endemic subspecies, being a semi-aquatic ground nester, would also have been ready fodder for the mongoose and other non-native predators (including humans), and was likely eaten to extinction in the last few centuries.

Jamaican Red Macaw (Ara gossei)

This is a real mystery species. Considered by some to represent a subspecies of the Cuban Red Macaw, the reality of this species is based on early post-colonial reports, and on the existence of a single 'lost' specimen. Because the other Greater Antillean islands had a native macaw species, it is not unreasonable to assume that Jamaica did as well. All species were apparently hunted to extinction. More mysterious is the purported prior existence of a second macaw species on Jamaica, the Red-tailed Blue-and-yellow macaw. Most ornithologists would agree that this is a highly doubtful record at best, but it does lend support to the notion that at least one macaw species formerly occurred on Jamaica.

Jamaican Giant Gecko

Another member of Jamaica's "probably extinct" herpetofauna, the Jamaican giant gecko, *Tarentola albertschwartzi*, was not described until 1998 when a specimen collected in the 1800s surfaced at the National Museums of Scotland (Sprackland and Swinney, 1998). Known only from this type specimen, and with no specific locality data, *T. albertschwartzi* remains a question mark. It was a large lizard that should not have escaped detection for over a century if in fact it had persisted. Moreover, although we know nothing of the species' ecology, its large size would certainly have predisposed it to becoming fodder for introduced mammalian predators. For now, this species must be considered as likely extinct.



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Jamaican Giant Galliwasp (Celestus occiduus)

Due to its large size, curious but poorly documented ecology, unclear historical distribution, and apparent rapid extinction in the 19th century, this is among Jamaica's most enigmatic modern species. Known only from mostly anecdotal accounts and a handful of museum specimens, there is no evidence to confirm the persistence of *C. occiduus* beyond the date of the last cataloged museum specimen—collected around 1860 (Henderson, 1992). The extinction of *C. occiduus* has been attributed to the introduction of the mongoose in 1872, but other factors may have been important (e.g., habitat degradation). The only published natural history notes on *C. occiduus* reported that it lived in swamps and fed on fish and fruit — an unusual but not inconceivable diet for a lizard (see Schwartz and Henderson, 1991). Most of the species' likely historical habitat has been either eliminated or severely degraded.

Recent habitat surveys focused on visiting former collection localities revealed that most of these areas are severely degraded and presumably unsuitable for *C. occiduus* (e.g., Black River Upper Morass, Bluefields) (McGinnity and Wilson, unpublished). And, while some interview information obtained from local residents and fisherfolk has been suggestive, recent survey and interview efforts have failed to uncover any compelling evidence that *C. occiduus* has persisted.

Interestingly, Pregil et al. (1992) reported finding numerous *C. occiduus* bones in a Cockpit Country cave, and they were thought to be on the order of 700 years old, making them close to contemporary. However, because the habitat does not agree with published accounts of *C. occiduus* habitat,



Crocodile habitat at Font Hill



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these old bones suggest the potential existence of a second 'giant' galliwasps species on Jamaica. But if we conservatively recognize only the swamp inhabiting *C. occiduus*, both the species and its historical habitat appear to have perished.

Small-eyed Galliwasps (C. microblepharis)

A smaller cousin of the Giant Galliwasps, this species was described from a single specimen (Underwood, 1959) and has not been recorded since. Although the species obviously existed in altered coastal habitat at the time of its discovery, subsequent tourism development has probably eliminated even its most marginal habitat. The species has been searched for repeatedly but unsuccessfully in recent decades (Hedges, pers. comm.); nevertheless, conducting additional surveys in and around the type locality is a conservation priority. For now the species must be regarded as likely extinct, and its habitat probably lost altogether as well.

Jamaican 'question mark' Poly lizard (Shaerodactylus gilvitorques)

This is another major "question mark" species, because its description was based on the only known specimen, which was collected in the middle of the 19th century. Unfortunately, the locality of that specimen was recorded only as "Jamaica", which precludes the potential for site-focused survey effort. However, given the secretive nature of *Sphaerodactylus* species generally, it may be premature to assume that this species is extinct. We should remain on the look-out.





Jamaican Black Racer Snake (*Hypsirhynchus ater*)

This was Jamaica's largest racer snake, and was apparently common over much of the island. Given the species' day-active habits, it is unsurprising that it seems to have disappeared shortly after the introduction of the mongoose in 1872. The last specimen was collected around 1920-1930, and there have been no credible reports since then. Unfortunately, this species is almost certainly extinct.

Jamaican Stream Frog (*Eleutherodactylus orcutti*)

This species disappeared rapidly from formerly reliable collection localities about 1985, and appears to be extinct, another casualty of the chytrid (*Bd*) fungus. The species certainly possessed the suite of ecological characteristics associated with *Bd* vulnerability (e.g., semi-aquatic, mid-high elevation), so its disappearance was tragic but not necessarily unexpected.

Other Missing Frogs

The Jamaican Leaf Mimic Frog (*Eleutherodactylus sisypodemus*) was not even known to science until the 1970's, and has not been recorded since 1984. Documenting the status of this species is a priority. Likewise, *E. junori* has not been collected since the 1980's, and this is a species that was thought to be declining at that time. Additional survey efforts are clearly warranted for several other species as well.

The 'Global Amphibian Crisis' and Other Worrisome Indicators

The aptly termed "global amphibian crisis" has been the subject of major international concern: nearly a third (32.5%) of all amphibian species are threatened with extinction – making them the most threatened vertebrate group (Stuart et al., 2004; Young et al., 2004). Birds and mammals, the only other vertebrate groups to have been assessed on a global scale, contain only 12% and 23% threatened species, respectively (Stuart et al., 2004). Reptiles are now being globally assessed using IUCN Red List criteria, and will likely show threat levels that also exceed those of birds and mammals. And within the West Indies in general, and within Jamaica in particular, reptiles, like amphibians, will probably show levels of endangerment that are at or near the highest worldwide.



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Because amphibians and reptiles are the most abundant vertebrates on Jamaica, their collective, extreme level of population and species endangerment must certainly have important implications for the future of the island's other inhabitants. Because of their highly permeable skin, and often dual, aquatic-terrestrial life styles, amphibians have rightly been hailed as superlative "bioindicators" of environmental health (Young et al., 2004). And the indications for Jamaica are most assuredly not good: over 80% of the island's amphibians are now threatened with extinction (Young et al., 2004). Terrestrial reptiles can also be used as indicators of overall environmental health, because they occur in similar habitats, and are sensitive to the same perturbations as are amphibians (Gibbons et al., 2000).

PART IV

Species Currently Under Threat

Essentially every component of Jamaica's rich assemblage of unique diversity is under threat. The island now has only one native land mammal, the Jamaican Hutia (or Coney). That species is globally threatened based on IUCN criteria, and 12 birds are also listed as globally threatened. In the treatment below I will focus on my personal favourites among Jamaica's vertebrate species -- amphibians and reptiles. I prefer to talk about these creatures in part because it is an area of familiarity, and I can speak with some confidence. And while there is still much to learn about these most ubiquitous members of the island's vertebrate fauna, the islands frogs and lizards are comparatively well known, and worthy of special focus due to their diversity and threatened status. Although nothing to look forward to, when Jamaica's reptiles are formally assessed for threat status using IUCN criteria they may well be shown to be even more threatened than the island's amphibians.

Even less is known about the island's other animals species – the invertebrates. The plants of Jamaica make up a huge and hugely complicated group that is well beyond my capacity to consider. So by sticking to lizards and frogs I can highlight a relatively well known group



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about which we can speak with some degree of clarity. So for the lovers of birds and bugs and plants, please excuse the scant attention directed at those important groups. We are going to focus on the ‘creepy crawlies’.

Sea Turtles

Sea turtles were historically common in Jamaican waters, and four species were known to nest on the island's beaches: the green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), leatherback (*Dermochelys coriacea*), and loggerhead (*Caretta caretta*). Habitat alteration and over-exploitation have decimated local sea turtle populations, especially in the last several centuries. Only the hawksbill now nests in Jamaica with any regularity — and it is Critically Endangered (IUCN, 2009). Overall, recent estimates suggest that Caribbean stocks of the green and hawksbill turtles have been reduced by 99.7% of historical abundance (McClenachan et al., 2006); Jamaica is probably on the high side of this regional average, with both species now being commercially and ecologically extinct.



Remains of a poached green turtle recovered by biologist

Most of Jamaica's major beaches on the north and southwest coasts have already been rendered unsuitable or greatly diminished for sea turtle nesting. Essentially all mainland beaches are vulnerable to future development or exploitation for tourism, or for settlements and commerce. And now even the island's offshore cays — including those in protected



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areas -- have been targeted by development interests. Such ambiguities concerning protected area status continue to plague management efforts. Together with inadequate enforcement, the precarious status of many 'protected' areas underscores the difficulty experienced, not just in Jamaica but in the region as a whole, in actuating the "protection" in protected areas management. The result has been the generation of numerous "paper parks."

Recovering Jamaica's sea turtle populations is no longer an option, given the loss of historical nesting beaches to development. However, hope remains for the protection of some nesting beaches, as well as for the management of turtles using offshore waters and cays. Several recent Jamaica Environment Trust (JET) initiatives funded by the EFJ are showing great promise. These efforts have been successful at garnering community driven action to protect and monitor nesting beaches, for example at Treasure Beach and Bluefields. This is a model that should be emulated elsewhere on the island.

Jamaican slider turtle (Trachemys terrapen)

This endemic turtle historically occurred in suitable freshwater habitats across the island, but has now apparently been extirpated or greatly diminished at many localities (Tuberville et al., 2005). Overharvesting appears to be the primary activity responsible for population reductions and extirpations. The species is listed as Appendix III by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), is ranked as Vulnerable on the IUCN's Red List, and is listed as Endangered by the United States Fish & Wildlife Service (USFWS, 2008).

However, *T. terrapen* is not covered by protective legislation in Jamaica. As a consequence, the harvest and sale of this species is legal on the island. Because its meat is reputed to contain "strong back" properties (i.e., an enhancer of male sexual performance), *T. terrapen* is at special risk, and is taken both opportunistically and through focused fishing effort. Reports of slider turtles being sold in the main Kingston market (Coronation) are



Jamaican Slider Turtle (Photo by Joseph Burgess)



disturbing, because source populations cannot sustain such a commercial demand. Perhaps more worrisome are reports of a new demand posed by recent Chinese immigrants. Another threat is the potential for invasion by the redeared slider (*T. scripta elegans*), and resulting competition or hybridization. Redeared sliders are commonly sold in Jamaican pet stores, so such an introduction appears to be inevitable rather than possible. To date however, survey efforts have not detected any established populations of *T. s. elegans*, nor has on-going genetic work revealed any evidence of hybridization (Parham et al., unpubl. data).

The island-wide status of *T. terrapen* is unknown, but on-going work initiated in 2007 (Parham et al., unpubl. data) will remedy this deficiency in the near future. In addition, Tuberville et al. (2005) suggested the existence of distinct northern and southern forms, and this possibility is now under investigation (Parham, pers. comm.). Resolving this taxonomic issue is a high priority objective, and will be a key driver of future conservation planning. In addition to the completion of survey and taxonomic studies aimed at establishing distribution and status, the endemic slider should be added to the list of species protected by the Wild Life Protection Act (WLPA). Based on a request from this author, NEPA recently (2009) began the consultation and evaluation process that should lead to *T. terrapen* being afforded full legal protection. A moratorium on the import and sale of *T. s. elegans* would reduce the potential for invasion, and public education initiatives might serve to reduce the probability of current captives being released or escaping into the wild.

American crocodile (Crocodylus acutus)

This wide-ranging species occurs from southern Florida to northern South America, and on the Greater Antillean islands of Cuba, Hispaniola, and Jamaica. In Jamaica, the species inhabits estuarine habitats, primarily along the south coast. Although the species' distribution is relatively well known on Jamaica, the current size and status of the population are not. The species is fully protected in Jamaica by the WLPA, and is listed as an Endangered species by the USFWS. Internationally, *C. acutus* is ranked as Vulnerable by the current IUCN Red List, and is a CITES Appendix I species. Continued habitat loss, persecution, and an undetermined level of harvesting represent the primary threats to the species in Jamaica. Survey efforts should seek to establish the status of *C. acutus* populations across the island, and in particular, to identify critical nesting and nursery habitats.



Treasure Beach crocodile (at Hope Zoo) about to be tagged.

The most important conservation objective is the protection of remaining coastal habitats. In particular, the loss of nesting beaches and adjacent lagoons (which serve as nursery areas) to tourism development should be arrested, especially given the recent large scale loss of such habitats. On the other hand, the most critical factor in their short-term survival may be the crisis-level illegal poaching for their meat, especially the role played by recent Chinese immigrants.

Blue-tailed Galliwasp (C. Duquesneyi)

Described from only a few specimens collected in the late 1930s at Portland Ridge (Parish of Clarendon), the species went unrecorded for half a century — in spite of collection efforts by experts searching in the type locality.

Then, in 1997, survey work in the central Hellshire Hills (Parish of St. Catherine), ca 25 km east of Portland Ridge, confirmed the extant status of the species and extended its known geographical distribution (Wilson and Vogel, 2000). The persistence of the species at Portland Ridge remains unknown, but the availability of suitable habitat suggests that it probably still occurs there. *C. duquesneyi* should be



Blue Tailed Galliwasp



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considered threatened due to limited range, on-going habitat loss, and the impacts of Invasive Alien Species (IAS). Nevertheless, the species appears to be more common than previously thought, at least in the remaining primary forest of the Hellshire Hills.

Protecting the Hellshire Hills and expanding existing IAS control efforts are the conservation priorities for this species. In addition, Portland Ridge should be surveyed to ascertain the species' status in its type locality. Portland Ridge supports two bird shooting clubs that have erected gates and actively discourage tree cutting; these habitat conservation activities should be continued. Finally, *C. Duquesneyi* would be an excellent candidate for re-introduction onto an IAS-free biodiversity reserve on the Goat Islands, which lie just west of the Hellshire peninsula and to the east of Portland Ridge (assuming the species does not already occur there).

Jamaican Skink

This threatened lizard, formerly considered to be a member of a more widely distributed Greater Antillean species, has recently been accorded full species status. As of 2011, Jamaica can add yet another unique taxon to its already impressive list of endemic species. Like the iguana, the skink probably occurred historically over much of the island's southern dry forest belt. Today, the Hellshire Hills are regarded as the skink's last stronghold (Vogel et al., 1996), although it occurs on Portland Ridge and perhaps in other, albeit disturbed, dry forest locations (e.g., Brazilletto Mountains). Although reasonably common in the Hellshire Hills, the species is subject to high rates of predation by the mongoose and feral cats, and its population densities are probably well below historical levels.

Should the Goat Islands be restored through the eradication of invasive mammals, the skink would be another ideal candidate for re-introduction onto such a protected, offshore biodiversity reserve. As with *C. duquesneyi*, the skink is assumed to have



Jamaican Skink



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occurred on the Goat Islands in historical times; if not, establishment of a population on the Goat Islands would constitute a conservation introduction — an intentional introduction designed to safeguard the species because of habitat loss and IAS on the mainland of Jamaica.

Jamaican Iguana (*Cyclura collei*)

I will end the discussion of Jamaica's threatened lizards by highlighting what may be the only case of a threatened Jamaican species appearing to be on the road to recovery. The endemic Jamaican iguana is the island's largest native land animal. Once considered to be extinct, *C. collei* was re-discovered in 1970, and again in



Jamaican Iguana

1990, in the same remote central portion of the Hellshire Hills (Woodley, 1971, 1980; Alberts, 1993). The 1970 “re-discovery”—the retrieval of a carcass from a pig hunter's dog—generated surprisingly little international interest; but perhaps of more consequence, there was no resident herpetologist in Jamaica at the time. The 1990 re-discovery was different. This time a live (though mortally wounded) specimen was brought in to the Hope Zoo in Kingston, and this time Jamaica did have a resident herpetologist in the late Peter Vogel, at the University of the West Indies, who helped form the Jamaican Iguana Research and Conservation Group (JIRCG), which embarked on a conservation crusade that is continuing today (Vogel et al., 1996; Wilson et al., 2004a, 2004b; Lewis et al., 2008).

Current conservation activities focus on population monitoring, studies of the species' ecology, invasive predator control, and advocacy for habitat protection. Ex situ activities include a multi-zoo captive breeding initiative and a headstart-release programme based on wild-caught hatchlings and operated out of the Hope Zoo. To date, around 150 headstarters have been repatriated into Hellshire, and these animals have demonstrated high survival rates and have integrated into the wild breeding population. Captive breeding was documented at the Hope Zoo in 2004, and at the Indianapolis Zoo (USA) in 2006. Foreign-born progeny will be used to establish a viable U.S.-based captive population that can serve as a hedge



against local extinction in Jamaica; only animals born and raised in Jamaica are used in repatriation efforts.

C. collei is listed as Critically Endangered by the IUCN (Red List), as an endangered species by the USFWS, and is a CITES Appendix 1 species. In Jamaica, the species is fully protected by the WLPA. The remnant population persists at low density in undisturbed sectors of the Hellshire Hills, especially in the south-central region. Overall population size is unknown, but published estimates suggest that only 50-200 adults may survive in the wild, perhaps fewer — and this assessment is consistent with the results of on-going population surveys (Wilson et al., unpubl. data).

Primary threats to the species include predation on young iguanas by cats and mongooses, predation on adults by dogs, and habitat loss resulting from charcoal production. Additional threats include the potential for large scale limestone mining and development projects. Most worrisome is the potential for residential or tourism development along the coast bordering the iguana's remaining habitat; the construction of access roads into this isolated region would lead to further habitat degradation and increased penetration by non-native predators, and would likely lead to the extinction of the iguana (cf. Iverson, 1978).

At present, this species appears to be “conservation dependent”. In the absence of on-going predator control and captive management efforts, *C. collei* would probably decline to extinction in the present century. An international workshop to revise the Species Recovery Plan (SRP) for *C. collie* was held in July 2006. A seminal goal in the SRP is the restoration of the Goat Islands through invasive species eradications, and the subsequent re-introduction of the iguana. Indeed, the re-establishment of an iguana population on these isolated off-shore cays is arguably the most decisive single action that can be taken to safeguard the species from extinction.

Once carrying capacity is reached on the Goat Islands, this population can be used to supplement the existing headstart programme by providing individuals for translocation back into the Hellshire Hills. In conjunction with enhanced predator control efforts this expanded re-introduction programme will be aimed at restoring natural iguana densities throughout the Hellshire Hills. Of course, this will only be possible if the remaining Hellshire forest is protected from charcoal burning and further



development. The actualization of habitat protection in the Hellshire Hills, and the restoration of the Goat Islands, will be determined largely by issues of a political nature.

Jamaican Boa

The endemic Jamaican boa (*Epicrates subflavus*) occurs widely but discontinuously across Jamaica, and is absent from high elevations (Tzika et al., 2008). The species is protected by the WLPA, it is a CITES Appendix 1 species, it is listed as Vulnerable by the IUCN (2009), and it is considered Endangered by the USFWS. The boa is Jamaica's largest terrestrial predator, and is known to consume threatened *Amazona* parrots (Koenig et al., 2007), and also the Critically Endangered Jamaican iguana (Wilson and van Veen, 2006). However, the boa is also a predator of the nonnative cane toad, and can succumb to the toxic assault resulting from toad ingestion, or attempts at same (Wilson et al., 2010).



Hellshire forest and coastline

Of course, the boa is helpless against the machete, and its population has no doubt suffered from centuries of persecution and habitat loss. No quantitative data on the boa population are available. Across the island it is considered uncommon to rare, but in areas recognized as its strongholds, such as The Cockpit Country, it can be described as “locally common” in suitable habitat (S. Koenig, unpubl. data). However, it is threatened wherever it occurs. Aside from habitat loss and the impacts of IAS predators, persecution by humans is probably the greatest threat to the boa (Tzika et al., 2008). On the other hand, introduced European rodents may provide an alternate food source that can enhance populations, but exploitation of this resource may put boas at risk of interacting with humans (Prior and Gibson, 1997). Current conservation initiatives include a public education campaign based out of the Windsor Research Centre in The Cockpit Country, where a mark-recapture and radio telemetry study is underway (S. Koenig, pers. comm.).



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Amphibians

Jamaica's native amphibian fauna consists of 21 described frog species, all of which are endemic to the island. A 22nd species (*Osteopilus* sp.) was independently discovered by R. Crombie and B. Hedges, and will soon be formally described (B. Hedges, pers. comm.). Of the 21 described species, 17 (81%) are considered threatened with extinction by the IUCN — giving Jamaica the dubious claim of harbouring one of the world's most endangered amphibian faunas (IUCN, 2009). The search for several 'lost species' continues.

PART V

General Conservation Activities

Habitat protection

A trend in the West Indies generally, is for conservation efforts to focus on coastal and marine habitats, rather than on interior, often more mountainous habitats. The latter areas are frequently viewed by governments as less valuable land with minimal use for development purposes. This is partly because the destruction and degradation of many natural forests in the West Indies had already occurred in the early colonial era, with the widespread removal of the primary exploitable resource (i.e., timber). Perhaps as a result of this perception, legislation to protect such areas has tended to lag behind legislation protecting coastal areas. Monitoring and enforcement objectives are also even more difficult to achieve in interior areas, which helps to explain why such efforts have ranged from inadequate to nonexistent.

The importance of preserving inland habitats notwithstanding, it was the coastal lowland areas that were ravaged first, and most thoroughly, and whose fauna is therefore perhaps at the greatest risk. First logged and settled, then long subjected to commercial and residential development, few natural or semi-natural coastal habitats remain in the West Indies generally, and on Jamaica in particular. These remnant habitats, especially those adjacent to white sand beaches, are now under severe threat from the more recent economic mainstay of the islands: tourism. Convincing governments and private landowners to conserve beach and littoral habitats



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is especially challenging, given the immediate economic rewards associated with tourism. An especially disturbing pattern is the courting of foreign investors to construct large hotels on what few beaches remain. This is a global problem, but also a conspicuously local one: one must merely



reference the '2nd Spanish Invasion'. Protecting the island's remaining beaches, and hence protecting remaining sea turtle and crocodile nesting habitats, is a conservation battle that will be hard to win. Eco-tourism development is one possible avenue that has worked quite successfully for conservation of sea turtles and their nesting habitats elsewhere in the region (Troeng and Drews, 2004).

Invasive Species Interventions

Regionally, previous anti-invasive species efforts have tended to focus on the eradication of mammals on small, offshore islets; control efforts on the larger main islands have been considerably less frequent. This is no surprise, because eradication is a feasible strategy on small islands, and the conservation impact of such actions has been convincingly demonstrated. Moreover, funding agencies and conservation organizations are understandably enamored with small island eradications because of the potential for tremendous and long-lasting conservation impact. The paucity of control efforts on larger islands is no doubt attributable to the constant inputs of labour and capital that are required, and the absence of a convenient or even foreseeable endpoint to the intervention activity. So, while the wisdom and efficacy of small island eradications is unquestioned, more effort should be directed toward control efforts in high diversity, inland habitats, especially on larger islands such as those in the Greater Antilles – particularly when small, off-shore islets are not available to serve as refuges that can be rendered invasive species-free and managed with relative ease.



On Jamaica, continuous control efforts directed at mammalian predators have been in effect for 15 years in the core Hellshire Hills habitat of the Critically Endangered Jamaican iguana. Yet the one obvious small island eradication project – the Goat Islands – has, inexplicably, never been initiated despite strong lobbying by the Jamaican Iguana Recovery Group and international conservation interests.

Because iguanas historically occurred on the Goat Islands, and because the cays are sufficiently small so as to render invasive species eradications feasible, the notion of establishing an alien-free biodiversity reserve has been discussed for 40 years, and remains a seminal goal in the IUCN's Species Recovery Plan for the iguana.

Conservation Goals and Imperatives

Short- and Long-term Goals

Given the high percentage of threatened species in Jamaica, urgent attention will be required to avert additional extirpations or extinctions. The most immediate conservation goal is therefore to ensure the persistence of the island's existing native species. But that is a crisis-driven activity aimed solely at averting extinctions; it ignores the important community and ecosystem roles played by healthy populations. Accordingly, the ultimate goal is the restoration of natural levels of abundance, such that the island's native species can play their historical roles in ecosystem function, and thus in the provision of ecosystem services (Thayer et al., 1984; Jackson, 1997; Bjorndahl and Bolten, 2003).

Obvious candidates for demographic restoration include the endemic iguana and sea turtle populations. The iguana is an important seed disperser and may therefore be critical to the maintenance of tree species diversity and forest structure (Alberts, 2000; Hartley et al., 2000). Further, historical levels of iguana reproduction would have constituted a major energetic contribution to the dry forest food web.

Similarly, historical sea turtle nesting levels would have represented a significant energetic input to the dynamics of coastal food webs (Bjorndahl and Bolten, 2003). And historical levels of foraging by green and hawksbill turtles probably maintained the natural state of sea grass beds, and sponge



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diversity on coral reefs (Thayer et al., 1984; Jackson, 1997, 2001; McClenachan et al., 2006; Hardt, 2009).

Of course, even small, seemingly inconsequential species may play crucial ecological roles; this is especially true for tropical islands, where small animals like frogs and lizards are often the numerically dominant vertebrates. So, for example, a small but abundant *Eleutherodactylus* or *Anolis* species may serve as prey for larger species and act as a natural control of insect populations. Experimental studies have even confirmed that *Anolis* lizards can influence vegetation structure on Caribbean islands (Spiller and Schoener, 1990).

Protective Legislation

The earliest law conferring legal protection to an animal species in Jamaica was fisheries legislation aimed at regulating the sea turtle industry. This came in 1711, and was aimed at controlling the take of sea turtle eggs; two centuries later, in 1907, the Morant and Pedro Cays Act regulated the take of sea turtles (and eggs) from those offshore areas. Further protection for sea turtles and other wildlife species came in 1945, with the introduction of the Wild Life Protection Act (WLPA); a 1982 amendment to the Third Schedule conferred legal protection to all life stages of five sea turtle species. Unfortunately, these more recent amendments highlight a major legislative flaw: the maximum fine for poaching or possessing a listed sea turtle is ca U.S. \$110 — what amounts to a modest licensing fee, given the low probability of prosecution and the high financial rewards of poaching. And, although the amendment also includes a provision for the seizure of equipment (including boats), that law has apparently never been enforced (Sutton et al., 2008).

In addition to the WLPA, various other laws confer protection to wildlife species occurring in protected areas such as national parks, forest reserves, game preserves, and sanctuaries. Because so many of the island's amphibian and reptile species occur in such protected areas, nearly all species have some form of legal protection in part or all of their range. Unfortunately, none of these laws are presently enforced effectively. Sea turtles, for example, continue to be harvested illegally, as do their eggs, and crocodiles continue to suffer from persecution and are now also subjected to poaching for an illicit trade in their meat.



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Overall, enforcement of environmental laws ranges from inadequate to nonexistent, but this is not a scenario unique to Jamaica. Corruption at the government level, and indeed at all levels of society (see Boxill et al., 2007), has severely hampered attempts to enforce legislation aimed at protecting species and habitats. Especially troubling is the potential for governments, and by extension individuals in government, to contravene established designations and sanction development projects in “protected” areas. Recently tabled plans to ‘develop’ the Pelican Cays – which lie in the middle of the Portland Bight Protected Area – is just the latest example of publically owned natural areas being put on the auction block. Font Hill in St. Elizabeth, though prominently marked as a “Nature Sanctuary” on Jamaican road maps, was recently almost sold to the Spanish for the creation of another mega-tourism development. A related problem is the manner in which Environmental Impact Assessments (EIAs) are now used in Jamaica as rubber stamps of approval for destroying the island’s diminishing store of wildlife habitat. Some areas are of such enormous and irreplaceable natural value, that they should simply not be up for sale.

Five Conservation Hotspots

Jamaica contains five discrete natural areas that are obvious priorities for biodiversity conservation, and hence are clear targets for effective protected areas management programmes. Indeed, delimiting critical areas for biodiversity conservation in Jamaica is straightforward: the protection and management of these five areas alone would confer protection to 100% of the island’s endemic bird, land mammal, and amphibian faunas, and nearly 100% of the island’s endemic reptiles. All of these areas are considered to be Important Bird Areas (IBAs) (BirdLife International, 2008) and are considered high priority sites for conservation by the Critical Ecosystem Partnership Fund (CEPF, 2010). In other words, these sites are recognized internationally as globally important repositories of Earth’s biological diversity. Given the importance these five sites, conservation attention should be directed there first, and with urgency.

Black River Lower Morass (BRLM)

Declared a wetland of international importance in 1997 through the Ramsar Convention, the BRLM includes Jamaica’s largest freshwater wetland.



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Altogether, this complex wetland area includes mangrove forests, raised limestone islands, remnant patches of swamp forest, and several types of herbaceous wetland habitat. Unfortunately, the BRLM has been severely degraded, first by extensive timber harvesting, mostly during the colonial era, more recently by drainage perturbations associated with sugar cane production, and by extensive loss and degradation of natural habitats for illegal cultivation. Another major problem is the proliferation of non-native plant and animal species, a phenomenon that is currently transforming the entire ecosystem. Nevertheless, the area's conservation importance is likely to grow as Jamaica's other wetland habitats continue to be lost or degraded. Make no mistake about it: the island's coastal habitats are under a major assault from development interests.

The presence of profitable ecotourism businesses focused on the crocodile, and based in Black River, together with the BRLM's Ramsar status, probably render this the most secure (from development) crocodile habitat on the island. On the other hand, Ramsar status does not in itself confer any protection, and may lead to complacency. In the case of the BRLM, no comprehensive monitoring system or management plan has been developed, much less implemented since the Ramsar designation — in contravention to both the spirit and obligations of the agreement. Many in Jamaica are under the impression that the BRLM is actually being managed and protected — a virtual park, to be sure.

Blue and John Crow Mountains National Park (BJCMNP)

Established in 1989, the BJCMNP was the first terrestrial National Park designated in Jamaica, and remains the only non-marine National Park in the country. The park encompasses 78,000 ha, and supports numerous plant and animal species found nowhere else on the island. The more eastern John Crow Mountains are a limestone formation ranging to 1140 m in elevation, whereas the Blue Mountains are of shale, igneous rocks, and minor limestones, and rise to 2256 m. The two mountain ranges are separated by the Rio



Blue Mountain habitat damage



Grande and its valley, an area that receives up to 5 m of rainfall annually—the highest recorded for the island. Both ranges contain (or contained) primarily moist and wet tropical forest, although the Blue Mountains also contain high elevation elfin woodland and cloud forest.

Despite its fully “protected” National Park status, the BJCMNP continues to suffer from heavy anthropogenic impacts. Inadequate management capacity has permitted continued degradation due to illegal agricultural and timber operations. A recent analysis of change in forest cover suggests that rates of habitat loss may have increased after the national park was designated (Chai et al., 2009). That study, however, as well as those that might paint a more positive picture, misses a major point: old growth primary forest is biologically distinct, but the distinction is not readily discernable from the analysis of remotely sensed images (see Evelyn and Camirand, 2003). In other words, a forest can be in steady qualitative decline, but in the absence of extensive ground-truthing, might appear to be recovering or even healthy. In 2009 a large scale illegal logging operation was uncovered in the BJCMNP; together with other less publicized selective timber operations, one can only assume that species diversity and forest structure have been greatly altered — even in this fully protected area. Disheartening indeed, that the country’s single terrestrial National Park is now being plundered of its most valuable resources – rare trees the took hundreds of years to reach maturity.

The Cockpit Country

A large, uplifted plateau of white limestone, where the chemical and physical actions of rain have resulted in its characteristic polygonal karst topography. The area has sustained centuries of human encroachment and timber removal, but nevertheless contains the island’s largest contiguous expanse of moist and wet broadleaf forest, and the highest concentration of endemic species. The area contains a large (22,344 ha) Forest Reserve, much of which is a single contiguous patch of forest that has been identified as being of special conservation value (Newman et al., 2010).

Current threats to The Cockpit Country include land conversion for small-scale agriculture, illegal timber harvesting, and the removal of young trees, especially for the production of “yam sticks”.



A recent and overriding threat is the government's plans to mine the area for bauxite. In fact, prospecting licenses issued in 2004 and renewed annually through 2006, permitted prospecting in 75% of The Cockpit Country Conservation Area. Those licenses were suspended amid opposition from the local and international conservation communities; a formal delineation of what actually constitutes "The Cockpit Country" is still pending. Preventing development in the area's remaining intact forest is critical, and this includes the construction of the roads and trails that invariably lead to increased levels of resource extraction and habitat degradation. Tabled discussions of The Cockpit Country for consideration as a World Heritage Site are encouraging, and should continue. However, because the Mining Act (1947) has precedence over all other environmental protection Acts, a ministerial decree declaring the area "Closed to Mining" will be the only legally recognized protection.

Dolphin Head Mountain and adjacent forests

An isolated, western feature of white limestone that boasts the island's highest level of site specific plant endemism (32.5%). The area contains several forest reserves, and is an Important Bird Area that encompasses 7301 ha (BirdLife International, 2009). Although the number of site endemic animal species is small, the area's isolation suggests that it probably contains a higher level of site endemism than is currently recognized, especially since the area is relatively understudied. For example, recent (2011) survey efforts revealed a frog that is almost certainly a species that will prove to be new to science.

Unfortunately, the unique forests of this area were ravaged during the colonial days, primarily for lumber, and for fuel to support sugar cane and lime industries. Extensive re-growth occurred (see Evelyn and Camirand, 2003), and substantial stands of moist tropical forest remained up until recent decades. Current threats to the remaining forests of this area include lumber removal (both legal and illegal) and slash and burn agriculture. One forest ecologist has described the situation as a disaster.

Hellshire Hills

An uplifted dome of white limestone fringed by mangrove wetlands, beaches, and rocky coastline. At ca 114 km², the area contains one of the



finest remaining examples of dry tropical forest in the insular Caribbean (fig. 1a). The area supports the only known population of the Jamaican iguana, and is a critically important refuge for a number of the island's other threatened species. The Hellshire Hills also represent an Important Bird Area (IBA), and are listed by the Alliance for Zero Extinction as a globally important site facing an imminent extinction (see Ricketts et al., 2005).



The Hellshire Hills, and essentially all of their remaining primary forests, are owned and managed by the Government of Jamaica. In addition to lying within the Portland Bight Protected Area (PBPA), a large government-owned portion of the area falls within the protected category of Forest Reserve. It is strictly illegal to cut trees in Hellshire, or to damage the habitat in any other manner.

Unfortunately, as elsewhere in Jamaica, lack of effective management has permitted rampant habitat loss, in Hellshire primarily for the production of charcoal. Large development projects, some dating back to the 1960s, are reported as shelved by the government, but nevertheless continue to be referenced on occasion; worryingly, the potential economic gains associated with tourism, together with the government's mandate to provide housing for Jamaica's increasing population, represent disturbing reminders that priorities can change.

Concluding Comments

A disturbing but unifying theme in the endangerment of insular Caribbean biotas is that human populations and their associated anthropogenic impacts are expanding and intensifying. Haiti represents a worst case scenario, where deterioration of the physical environment has precipitated an extinction crisis of as yet unknown proportions (Hedges and Woods, 1993). Although significant differences between Haiti and Jamaica are evident



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(e.g., island size, physical and cultural histories), our eastern neighbour nevertheless represents a realistic if depressing model of the likely fate of Jamaica's natural habitats and inhabitants. So let Haiti serve as a red flag. Jamaica should take note of the Haitian paradigm: it is a country that appears to be on a similar trajectory. The solution is as simple as its implementation is complicated: contain population growth, reduce consumption, and stop cutting down trees. The latter is worth repeating: stop cutting down trees.

But Keep Hope Alive: Lessons and Directives for the Youth

The battle to save Jamaica's remaining natural habitats and currently threatened species is going to be uphill, and steep, and the opposition will be formidable. So it must be the young legs of the country that lead this charge. Today's school agers must ultimately wage this fight, because they have the most at stake – their future existence in a healthy Jamaican environment. The new generation should also know only too well, that they cannot trust the previous generation to leave them a viable environment. They must fight this battle themselves -- for themselves, and for the generations to follow.

In this regard, EFJ's contributions to environmental education initiatives offer considerable hope. Indeed, the only hope for the Jamaican environment, and by extension, for many Jamaican species, is a major change in the way the natural environment is viewed and treated. The responsibility for this sea change rests squarely on the shoulders of the younger generations, because they represent the last hope. Environmental education programmes provide welcome promise that a new generation may yet embrace an improved sense of environmentalism – to view the environment as something to be nurtured and protected for long term sustainability, rather than as an unending supply of extractable resources, or as chunks of real estate that can be sold for fast dollars. After all, Mother Earth is our ultimate and benevolent matriarch, and we should treat her with the appropriate care and respect due all mothers. After all, it is the right thing to do, and it is in our best interest.



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Mission Statement

The mission of the Environmental Foundation of Jamaica is to serve the public good by promoting and implementing activities designed to conserve and manage the natural resources and environment of Jamaica in the interest of sustainable development and to improve child survival and child development.

Vision

The EFJ will be a national leader in the Child Development and Environment Sectors by the year 2012, with effective partnerships to ensure sustainable development in the programmes, policies and practices of the public sector, private sector and civil society.

Core Values

- Good governance that dictates transparency of process and accountability.
- Supporting partnerships and development initiatives consistent with our mission.
- Respecting the value of initiatives coming from the public and private sectors and channeling this interest into partnerships with community groups and other organizations of civil society.
- Developing and maintaining relationships that are consistently ethical while being effective and efficient in doing the organization's business with members, clients and staff.
- Non-discrimination in relation to gender, race, creed and age.

