# Going Out on a Limb: An Estimate of the Number of Treeboas (*Corallus grenadensis*) on Grenada

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During a recent visit to Grenada and a meeting with personnel of the island's Division of Forestry, I was asked how many treeboas (*Corallus grenadensis*) occur on the island. I was surprised at the question, and I responded that I had no idea. Back in my museum office, however, I started to think about the question and wondered if I could, indeed, calculate a very rough estimate, knowing full well that it was an exercise fraught with many pitfalls.

Eight thousand years ago, about 63% of Grenada was covered in forest; in 2000, forests covered only an estimated 15% of the island (World Resources Institute 2003). Today, Grenada (311 km$^2$) is a patchwork of wooded and open areas dominated by cropland, crop/natural vegetation, shrublands, savanna, and grasslands (World Resources Institute 2003, Helmer et al. 2008), in large part due to its colonial history and the extensive estates that once dominated the island's landscape. For example, in 1772, 125 of 334 estates on Grenada were devoted to sugar cultivation (Brizan 1984), and those 125 estates extended over nearly 13,000 ha, accounting for 42% of Grenada's surface area. In 1824, at least 342 estates were still in operation and agricultural practices had effectively parceled the landscape into many isolated patches of woodland (Brizan 1984) separated by large expanses of treeless cropland. Although many fewer estates are active now, agricultural practices of 150–250 years ago might, today, impact the ecology of an arboreal snake (Henderson 2002, 2008).

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Edges along paved roads with vehicle and pedestrian traffic and hotels still harbor treeboas.

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Edge habitat at Westerhall in February 2006.

Taking into account all the habitat transitions, enclaves of human activity, potential *Corallus grenadensis* habitat, and other factors that can impact animal distributions would be next to impossible, as would calculating population densities of treeboas for all the many possible variables of habitat that occur on the island. For these reasons, any attempt to determine the number of individual *C. grenadensis* on Grenada could go horribly wrong.

## Methods

As nocturnally active *Corallus grenadensis* is virtually restricted to edge situations in a variety of habitats, I used the lengths of roads (primary, secondary, and 4-wheel drive roads) and rivers to ascertain an approximate value for a portion of edge habitat on the island. Based on hundreds of hours of searching for treeboas, I used the value of 1.0 m on either side of a road or along the banks of a river as to how far active treeboas penetrated the "edge" off a road or riverbank; although by day, the diurnally quiescent boas will rest on arboreal perches deeper than 1.0 m into wooded areas. Therefore, the length of road or river x 2.0 provided the area in which treeboas would occur along a stretch of edge habitat. That value was then converted to hectares. For example, 100,000 m of road x 2.0 m = 200,000 m$^2$ = 20 ha. Once calculated for each type of road and for rivers, I subtracted 9% of the


A Grenada Bank Treeboa (*Corallus grenadensis*) with a noticeable bulge in its stomach. It was encountered along a dirt road at Les Avocats (St. David Parish).

value as approximately 9% of Grenada's surface area occurs at elevations higher than 500 m above sea level, and treeboas are rare or absent at those elevations.

Edge habitat for *C. grenadensis*, however, is not restricted to roads and rivers. Edge can occupy various levels in a given habitat (e.g., Henderson 2002: Fig. 3.1), and it can occur anywhere where tree crowns are contiguous and far removed from a road or a river (e.g., bordering an agricultural field). Using the Rule and Path functions on Google Earth®, I measured the amount of edge habitat in 25 randomly selected plots below 500 m. Those plots had a mean area of 1.88 ± 0.19 $km^2$ (range = 0.32–3.84 $km^2$). I divided the total area of Grenada (minus the 9% above 500 m) by the total area of the 25 plots (47.09 $km^2$). That figure was multiplied by the total amount of edge habitat calculated from the 25 plots (mean = 2.80 ± 0.34 km; range = 0.0–6.57 km; total = 70.18 km) to provide the amount of miscellaneous edge habitat below 500 m on the island (= 422 km). Not being along a road or river, there is only one side of edge, so the amount of edge resulted in an additional 42 ha of miscellaneous treeboa habitat.

Based on extensive ground-level experience at various sites in Grenada, I know Google Earth did not provide the necessary resolution to measure all woodland edge situations. However, since not all edge habitats are suitable treeboa habitat (see below), I have not attempted to factor in this "unaccounted" edge.

I determined densities of *C. grenadensis* at several localities between 1992 and 1998 by visual encounter surveys wherein snakes were counted along transects of known length and over periods of weeks at different times of the year. Mean counts were extrapolated to number of boas/hectare. This simplistic method is likely more useful with species of *Corallus* than with any other nocturnally active snake species in the world. Due to their arboreality and the reflection from their eyes, *C. grenadensis* is easily visible from 50 m or more at night. Nevertheless, an active boa whose head is shielded by foliage may well go unobserved. The sites at which density estimates were made would be considered either secondary roads (e.g., Beausejour Estate) or 4-wheel-drive roads (e.g., Mt. Hartman Bay, Westerhall Estate, Pearls), where the habitat was either mixed orchard trees and native vegetation, or mangrove-*Acacia* ecotone, and treeboa densities ranged from 4/ha to 69/ha.

My rationale for densities attributed to road, river, or miscellaneous edge is as follows: For primary roads, which often run through human population centers and generally are suboptimal treeboa habitat, I used the lowest density I calculated at any site, which was 4/ha. For secondary roads, I used the lowest density I recorded along the road at Beausejour Estate, a value of 19/ha. Along 4-wheel drive roads, I used the average of low-end values for densities recorded at Pearls and Westerhall estates, yielding an estimate of 36/ha. For rivers, I used the average of densities calculated along the road above the Beausejour River and along the river itself, giving a value of 23/ha. Finally, for miscellaneous edge habitat (no roads or rivers), I used the high value of 19/ha for the trail at Mt. Hartman Bay, a site that I considered borderline good treeboa habitat. Henderson (2002) provided detailed information and photographs of the sites.

The methods used here have shortcomings, some obvious, others more subtle. For example, according to Landsat imagery, Grenada has 308 ha of high-medium density urban or built-up land (Helmer et al. 2008). Some of this land-use category is all concrete and commercial buildings and certainly devoid of trees and treeboas, but some of it does support trees with contiguous crown habitat, and treeboas do occur in some very unlikely situations. Likewise, 2,343 ha were designated pasture, hay, or inactive agriculture (e.g., abandoned sugarcane) (Helmer et al. 2008). Although one thinks of sugarcane as treeless, I have encountered *C. grenadensis* in trees bordering active and abandoned sugarcane fields. Therefore, again, I have made no attempt to further refine the amount of land that may or may not harbor treeboas.

Table 1 provides road, river, and miscellaneous habitat lengths, number of associated hectares, and treeboa densities for each.

## Results

My calculations resulted in a total of 360 ha of potential *Corallus grenadensis* habitat. Given the various densities used to calculate this figure (Table 1), I estimate the total population of *C. grenadensis* on Grenada to be approximately 7,000–8,000 individuals.

## Discussion

I have suggested (most recently in Henderson 2008) that humans, through much of their shared history with *Corallus grenadensis*, have contributed to an increase in treeboa numbers by increasing the amount of edge habitat owing to the distribution of estates and agricultural practices. I also have suggested that numbers of treeboas may be on the decline since a likely peak in the late 19th century (Henderson 2008); certainly the past 10–15 years have seen declines at some sites (e.g., Henderson et al. 2009), possibly

**Table.** Amount of potential habitat, population densities, and number of *Corallus grenadensis* on Grenada. Road and river lengths were provided by the Land Use Division (Ministry of Agriculture) on Grenada and based on a 1986 map. Miscellaneous habitat was calculated based on measurements off Google Earth.

| Edge Type | Length (km) | No. of Hectares | Treeboa Density | No. of Treeboas |
|---|---|---|---|---|
| Primary Roads | 275 | 55 | 4/ha | 220 |
| Secondary Roads | 269 | 54 | 19/ha | 1,026 |
| 4-wheel Drive Roads | 232 | 46 | 36/ha | 1,656 |
| Rivers | 816 | 163 | 23/ha | 3,749 |
| Miscellaneous | 422 | 42 | 19/ha | 798 |
| **TOTAL** | | | | **7,449** |

due to a decrease in land devoted to agriculture and an increase in urban or "built-up" land (Helmer et al. 2008), an associated loss of edge habitat, and changes in the composition and structure of forested situations. Abiotic factors, too, have the potential to impact the ecology of treeboas in Grenada (Henderson 2002, Sun et al. 2001), but here I will focus on two variables I believe most likely to influence *C. grenadensis* distribution and numbers: Food and habitat.

*Corallus grenadensis* preys predominantly on anoles (*Anolis aeneus* and *A. richardii*) and introduced rodents (*Mus musculus* and *Rattus rattus*). Fieldwork by Harris et al. (2004) at two sites for which I determined densities of *C. grenadensis* (Mt. Hartman and Westerhall), calculated population densities of 830–12,250/ha for the two anole species combined. Although density estimates of the rodent species are lacking, many hundreds of hours of nocturnal fieldwork on Grenada suggest that they, like anoline prey, are abundant and widespread.

Recent (2010–11) fieldwork at Westerhall emphasized the importance of the composition and structure of plant communities within treeboa habitat. Seventeen years had passed since a previous project at Westerhall addressed habitat use (Henderson and Winstel 1995) and calculated treeboa densities (Henderson 2002). Hurricane Ivan hit Grenada in 2004, and many wooded areas were devastated, including that at Westerhall (Henderson and Berg 2005). Trees were leveled and what was once ideal *C. grenadensis* habitat was transformed into sub-marginal habitat with little contiguous crown vegetation along the transect worked in 1993. By 2010, however, the transect was again wooded along its entire length, but the composition and structure had changed dramatically. Fifty 10-m transect sections (out of a possible 122) harbored mango trees in 1993, yet only four did so in 2010. Additionally, 29 sections had evidence of sugarcane cultivation in 1993 compared to none in 2010, and 31 sections had breadfruit trees in 1993, but only one in 2010. In 1993, only 33 sections were 100% uncultivated while all 122 sections were uncultivated in 2010. Although anoles were still common throughout the transect in 2010 and rodents were frequently observed, the mean number of treeboa observations/night was 1.6 ± 0.2 (range = 0–3) compared to 9.5 ± 0.7 (5–15) in 1993. Searches for treeboas in nearby (25–50 m distant) stands of trees that were not devastated by Ivan (but separated from the study transect by treeless areas or solitary trees) quickly produced more boas than extensive searches along the transect, strongly suggesting that vegetation composition and structure are critically important elements of *C. grenadensis* habitat.

I first started doing treeboa surveys on Grenada in 1988. These initial surveys were undertaken merely to get some idea as to what kinds of habitats the snakes preferred, and what kinds were avoided. My early impressions were that *C. grenadensis* occurred almost everywhere and in almost any conceivable habitat on the island. Over time and many visits to Grenada, my impressions were refined. Treeboas did indeed occur in a wide variety of habitats (i.e., in 12 of 18 land-use categories; Henderson 2002: Table 3.1), often in proximity to human activity, but they did not occur everywhere. Nevertheless, before attempting this exercise, I would have thought treeboa numbers to be much higher than my calculated total. However, edge habitat, although certainly not uncommon, is limited. Grenada has about 31,100 ha of surface area and, based on my methods, only 1.2% of that area is potential habitat for *C. grenadensis*. My estimates might be (and hopefully are) conservative, but I am convinced that treeboas in Grenada do not occur in the tens of thousands, but, at best, in the relatively low thousands (8,000–15,000), and that suitable edge habitat is the limiting factor impacting both distribution and their numbers.

## Acknowledgments

I thank Mr. Michael Mason, Land Use Officer in the Ministry of Agriculture, Forestry, and Fisheries for providing critical information on roads and rivers in Grenada. Thanks also to Mr. Aden Forteau, Head, Forestry Division, who prompted this exercise by asking me how many treeboas occur on Grenada. Mike Pauers provided helpful advice, Craig Berg, Josh Kapfer, and Rich Sajdak noted numerous shortcomings in this exercise, and Bob Powell provided editorial options. I have been fortunate to work with a wonderful cohort of associates over the years in Grenada, including Craig Berg, Joel Friesch, Ky Henderson, Rose Henderson, John Murphy, Rich Sajdak, and Al Winstel.

## Literature Cited

Brizan, G. 1984. *Grenada: Island of Conflict*. Zed Books Ltd., London.

Harris, B.R., D.T. Yorks, C.A. Bohnert, J.S. Parmerlee, Jr., and R. Powell. 2004. Population densities and structural habitats in lowland populations of *Anolis* lizards on Grenada. *Caribbean Journal of Science* 40:31–40.

Helmer, E.H., T.A. Kennaway, D.H. Pedreros, M.L. Clark, H. Marcano-Vega, L.L. Tieszen, T.R. Ruzycki, S.R. Schill, and C.M.S. Carrington. 2008. Land cover and forest formation distributions for St. Kitts, Nevis, St. Eustatius, Grenada and Barbados from decision tree classification of cloud-cleared satellite imagery. *Caribbean Journal of Science* 44:175–198.

Henderson, R.W. 2002. *Neotropical Treeboas: Natural History of the* Corallus hortulanus *Complex*. Krieger Publishing Co., Malabar, Florida.

Henderson, R.W. 2008. The shared history of humans and treeboas (*Corallus grenadensis*) on Grenada: A hypothetical excursion. *Iguana* 15:198–203.

Henderson, R.W. and C.S. Berg. 2005. A post-Hurricane Ivan assessment of frog and reptile populations on Grenada, West Indies. *Herpetological Bulletin* (91):4–9.

Henderson, R.W. and R.A. Winstel. 1995. Aspects of habitat selection by an arboreal boa (*Corallus enydris*) in an area of mixed agriculture on Grenada. *Journal of Herpetology* 29:272–275.

Henderson, R.W., C.S. Berg, B. Harrison, and D.T. Yorks. 2009. Notes on an unexpected decline of a population of *Corallus grenadensis* (Squamata: Boidae) in Grenada, West Indies. *South American Journal of Herpetology* 4:186–192.

Sun, L., R. Shine, Z. Debi, and T. Zhengren. 2001. Biotic and abiotic influences on activity patterns of insular pit-vipers (*Gloydius shedaoensis*, Viperidae) from north-eastern China. *Biological Conservation* 97:387–398.

World Resource Institute. 2003. Earthtrends. <http://earthtrends.wri.org>.

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An alternate, uncommon defensive body-coiling configuration in *Amphiuma tridactylum*; note the head and tail protruding from underneath. Food items, Earthworms (*Lumbricus* sp.) and Red Swamp Crayfish (*Procambarus clarkii*) are present.