# Distribution and Habitat Use by the Critically Endangered Stout Iguana (*Cyclura pinguis*) on Guana Island, British Virgin Islands

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The Stout Iguana (*Cyclura pinguis*, Fig. 1) is a large lizard endemic to the Greater Puerto Rico Bank (Lazell 2002, Lazell 2005). It is one of the largest species in the genus, and, like all congeners, is imperiled. *Cyclura pinguis* is listed as Critically Endangered by the International Union for Conservation of Nature (IUCN 2004) and as Endangered by the U.S. Fish and Wildlife Service (USFWS 1999). For at least several hundred years, these lizards have presumably been confined to the 4,000-ha island of Anegada in the British Virgin Islands, where they currently face many threats, including non-native mammals. For example, introduced ungulates, such as sheep, compete directly for resources. By the early 1990s, only an estimated 164 individuals remained on Anegada (Mitchell 1999). Because of the continued decline of the iguana population on Anegada, eight individuals were introduced to Guana Island, British Virgin Islands between 1984 and 1986 (Goodyear and Lazell 1994), with subsequent introductions to Necker and Norman islands. All three of these islands have the advantage of being privately owned, thus restricting human access, and harbor few introduced mammals (Perry and Gerber 2006). The most recent population estimates for the islands are 250 individuals on Anegada (Gerber 2004), 130 on Guana Island, and 30 on Necker Island (Perry and Mitchell 2003).

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**Fig. 1.** Stout Iguanas have been very successful at establishing themselves on Guana. The hundreds of iguanas living on the island are all descended from just eight individuals released in the 1980s.


**Fig. 2.** Although translocated from the flat, sandy island of Anegada, the population on Guana appears to be thriving in an area with considerably more topographic relief.

Despite substantial conservation concerns, little is known about the natural history of this species (but see Goodyear and Lazell 1994, Mitchell 1999, Levering and Perry 2003, Perry and Mitchell 2003, Lazell 2005, Perry et al. 2007). Because habitat use has never been studied in the Guana population, we sought to determine age-class specific habitat use on the island. As Guana Island differs markedly from Anegada Island in both geologic substrate and topography (Fig. 2), these results could have important habitat management implications. A second objective was to examine the distribution of iguanas on Guana Island. Over 15 years ago, Goodyear and Lazell (1994) noted that the distribution of iguanas on Guana appeared patchy, with no individuals observed in the northeastern or southern sections of the island.

## Methods

In 2009, every marked trail on the island was surveyed by a group of two to three people, and most trails were revisited at least once and up to three times on separate occasions (Fig. 3). Because we could not determine if we were observing new or previously sighted individuals, we recorded all locations if an iguana had not been observed in the immediate vicinity within the past two hours. Once an iguana was observed, we recorded the time of day, percent cloud cover, location on the island relative to trails and/or landmarks, and general habitat at the spot of initial observation. Location coordinates (UTM, NAD83) were recorded using a geographic positioning system (Garmin International, Inc., Olathe, Kansas), and the lizard was categorized as an adult, yearling, or hatchling based on size. Once the iguana moved from the initial point of observation, we recorded air temperature with a mercury thermometer at 5 cm above the ground. We then positioned a 3-sided ½ m x ½ m quadrat at the original location and oriented it toward the north (Fig. 4). We took photographs of both the quadrat (ground cover) and the canopy cover above the quadrat with a digital camera (Canon, USA, Inc., Lake Success, New York) held 1 m above the ground. Both ground and canopy cover pictures were analyzed using SamplePoint, version 1.48 to determine percent composition of cover types. We categorized ground cover types as herbaceous vegetation, woody vegetation, litter, bare ground (including rocks < 2.5 cm in diameter), rock (> 2.5 cm in diameter), man-


**Fig. 3.** Whereas many iguanas along the trails would flee at the approach of people, individuals living in close proximity to humans on Guana Island were readily visible during the surveys.


ROBERT POWELL

Despite substantial conservation concerns, little is known about the natural history of the Stout Iguana (*Cyclura pinguis*). This individual sought a shady retreat from the early afternoon heat on Guana Island (British Virgin Islands).

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**Fig. 4.** A quadrat was placed at the site where an iguana was encountered and a photograph was taken. Photographs were later analyzed with computer software to determine percentage of ground cover types.

JENNY STROVAS

**Fig. 5.** Hatchling iguanas were generally captured using a noose.

SARAH WULFF

**Fig. 6.** Once an iguana was captured by researchers, length and weight measurements were taken and habitat variables measured.

made, or unknown (ground cover we could not identify from our photographs). Canopy was classified as either vegetative cover or sky. A random direction was selected and the quadrat was repositioned 5 m from the original location along that azimuth in order to establish random locations to compare with encounter locations. Ground cover and canopy cover photographs were then taken in the same fashion as before. Differential use of cover types between both age classes and between encounter and random locations were analyzed using a chi-square analysis in Tadpole, version 2.

We recorded slope and aspect at each location. Aspect was divided into five ordinal categories: 315–44°, 45–134°, 135–224°, 225–314°, and flat. Finally, a designation of developed (if location was in close proximity to man-made structures) or undeveloped was assigned to each location.

We attempted to capture hatchling and yearling iguanas with nooses (Figs. 5 & 6). Captured hatchlings were weighed to the nearest gram, snout-vent length (SVL) and tail lengths were measured, individuals were marked with a unique number using white correction fluid for identification purposes (Fig. 7), and were released at the site of capture. Repeated observations of these individuals were recorded as re-sightings and habitat measurements were taken at these new locations and at associated random points.

Locations of iguanas observed by other researchers not directly involved with the project were marked with flagging by the observer. The primary investigators later visited these locations and recorded the same environmental measurements excluding temperature, percent cloud cover, and time of day (if not recorded during initial sighting). Additionally, for distribution analysis only, we used location data for both adult and hatchling iguanas recorded by researchers in 2004–2008.

General slope, aspect, and elevation for each location were compared to data collected at random points in 2008 during an ecological study of the island. Random habitat data points were collected along transects adjacent to trails throughout the island. Those data are representative of habitats in which we could have encountered iguanas during our surveys. A one-way ANOVA was used to compare general slope and elevation among adult iguana locations, hatchling iguana locations, and random sites. Least

SARAH WULFF

**Fig. 7.** Hatchling iguanas were temporarily marked with white correction fluid by researchers to aid in identification if they were encountered again. Here, iguana no. 11 basks on a stone wall.

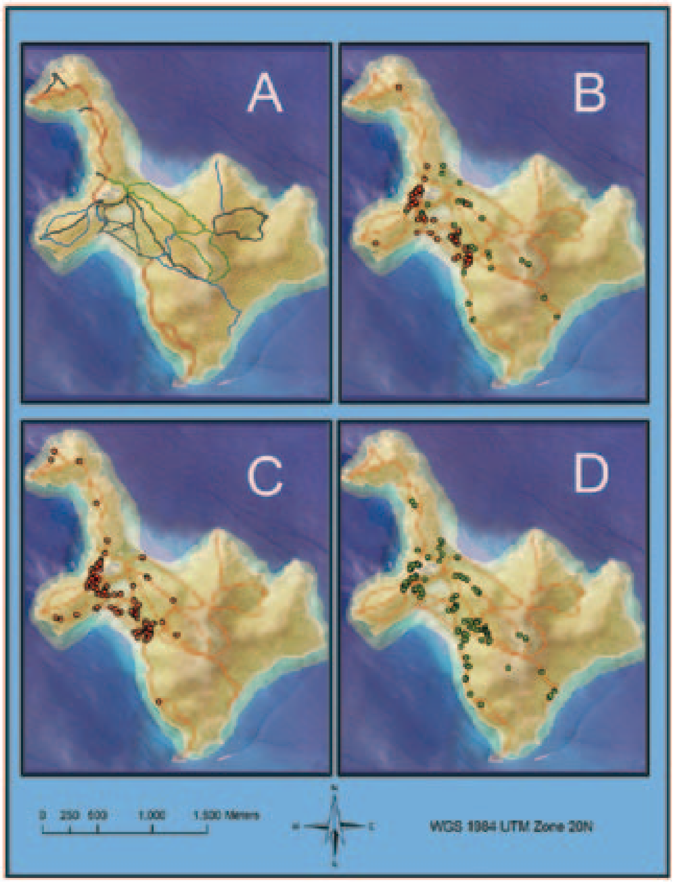


**Fig. 8.** Sampling effort and distribution of iguanas on Guana Island, BVI: (A) 2009 sampling effort based on number of times each trail was sampled (once-black, twice-blue, three times-green, four times-red); (B) 2009 iguana locations based on sampling effort from map A (green-adult and red-hatchling); (C) 2004–2009 locations of hatchling iguanas; (D) 2004–2009 locations of adult iguanas.

Significant Difference (LSD) post hoc tests were performed to evaluate pair-wise differences. Differences between general aspect among adult iguanas, hatchling iguanas, and random locations were compared using a chi-square test. The general aspect of the location at which an iguana was encountered was compared to time of day using a chi-square test. Time of day was classified into four categories: Early morning (beginning of surveys to 1000 h), late morning (1001–1200 h), early afternoon (1201–1400 h), and late afternoon (1401 to end of surveys). Finally, differences between iguana age class (adult or hatchling) and use of developed areas was analyzed using a chi-square test. Iguana locations within close proximity to human structures were categorized as "developed," whereas locations on or adjacent to trails were assumed to be representative of natural habitat across the island and were classified as "trails." All tests were performed within SPSS (SPSS Inc., Chicago, Illinois) with an alpha level of 0.05.

All UTM coordinate locations were mapped and analyzed in ArcGIS 9.3 (ESRI, Redlands, California). UTM coordinates were added and created into a shape file for adult iguanas, hatchling iguanas, and trails. Trails were categorized into classes based on numbers of surveys we conducted during 2009 to denote sampling effort. These shapefiles were then overlaid on a digital elevation model (DEM) and hillshade raster file to produce an elevational gradient map. Overall iguana distribution, elevational distribution, and age class distribution can be extrapolated from these maps.

### Results

In 2009, we recorded 96 iguana sightings (43 adults, 52 hatchlings, 1 yearling). Sampling efforts are illustrated in Fig. 8, Map A, and iguana locations are illustrated in Fig. 8, Map B. All iguana sightings from 2004–2009 (N = 285: 123 adults, 160 hatchlings, 2 yearlings) are illustrated in Fig. 8, Maps C and D.

The majority of hatchling sightings (75%) occurred in developed areas, whereas the majority of adult sightings (51%) occurred on or near trails throughout the island (Maps C & D). Hatchlings represented 65% of the sightings in developed areas; however, adults represented 63% of the sightings on trails. Sightings of age class and location on the island differed significantly. No iguanas of either age class were observed on the eastern half of the island. This appeared to correspond strongly with feral sheep spoor, such as tracks, scat, and evidence of foraging on vegetation (Fig. 9).

Microhabitat characteristics and canopy cover for random versus iguana sightings are summarized in Table 1. Hatchlings were most frequently found in areas of bare ground (30.8%) with 55% cover, whereas adults were most frequently found in areas of leaf litter (54.7%) with 80% cover. When age classes were pooled, the difference between iguana and random sites for microhabitat or cover were not significant (Table 1). However, we did find a significant difference between adult and hatchling sightings for both microhabitat and canopy cover.

Slope, elevation, and aspect data are summarized in Table 2. Adults were generally encountered on steeper slopes and at higher elevations than hatchling iguanas. Random points along trails often had steeper slopes and higher elevations than both adult and hatchling iguana locations.

CLINT BOAL

**Fig. 9.** Most groundcover and low-hanging vegetation on the eastern half of Guana Island has been consumed by feral sheep. Feral sheep compete directly with Stout Iguanas for food, and their presence may account for the lack of iguanas on this part of the island.

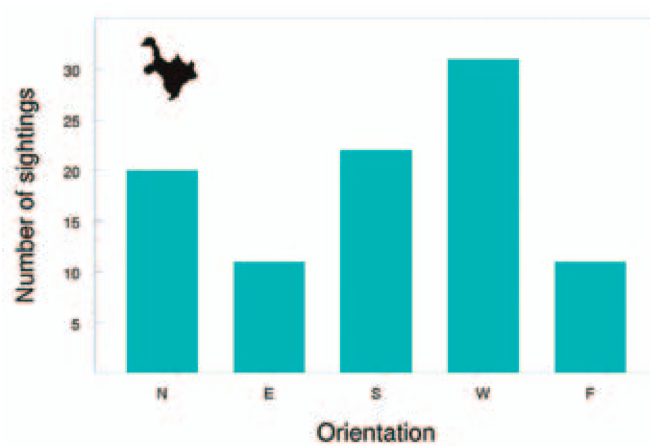


**Fig. 10.** Iguanas found on northern, eastern, southern, western, or flat aspects of Guana Island, BVI during 2009 sampling.

**Table 1.** The mean percentage of microhabitat characteristics or canopy cover (± 1 standard deviation) for random and all iguana locations in 2009 on Guana Island, BVI. Iguana locations then were divided into adult and hatchling categories. Differences between both adult and hatchling microhabitat and canopy cover use were statistically significant at $p < 0.005$.

| | Herbaceous | Woody | Litter | Bare | Rock | Manmade | Unknown | Cover | Open |
|---|---|---|---|---|---|---|---|---|---|
| Random | 10.1 ± 21.2 | 4.2 ± 9.0 | 44.6 ± 30.2 | 16.7 ± 25.5 | 14.3 ± 19.3 | 9.8 ± 28.5 | 0.5 ± 1.6 | 71.0 ± 32.2 | 29.0 ± 32.2 |
| All Iguanas | 9.7 ± 20.0 | 4.4 ± 7.9 | 41.3 ± 31.9 | 23.7 ± 30.8 | 13.7 ± 19.2 | 7.1 ± 24.2 | 0.1 + 0.5 | 66.3 ± 30.9 | 33.7 ± 30.9 |
| Hatchlings | 13.8 ± 24.0 | 4.4 ± 8.3 | 29.6 ± 27.8 | 30.8 ± 34.5 | 13.2 ± 20.4 | 8.3 ± 26.2 | 0.1 ± 0.5 | 55.4 ± 34.2 | 44.6 ± 34.2 |
| Adults | 4.2 ± 11.7 | 4.3 ± 7.1 | 54.7 ± 32.0 | 15.8 ± 24.5 | 14.9 ± 18.2 | 5.9 ± 22.5 | 0.2 ± 0.6 | 78.9 ± 20.6 | 21.1 ± 20.6 |

**Table 2.** The average slope and elevation (± 1 standard deviation) for each location class, and percentage of locations within each aspect category in 2009 on Guana Island, BVI. Differences among adult, hatchling, and random locations for both slope and elevation were significant at $p < 0.001$. Significant differences at $p < 0.001$ were detected when comparing adult and random aspect as well as hatchling and random aspect, but no significant difference existed between adult and hatchling aspect.

| | Slope (degrees) | Elevation (m) | Aspect (% of occurrences) | | | | |
|---|---|---|---|---|---|---|---|
| | | | North | East | South | West | Flat |
| Adult | 20 ± 11 (0–38) | 51 ± 52.6 (5–223) | 16.3 | 16.3 | 20.9 | 37.2 | 9.3 |
| Hatchling | 12 ± 12.0 (0–38) | 31 ± 20.9 (7–80) | 25.0 | 7.7 | 25.0 | 30.8 | 11.5 |
| Random | 34 ± 14.3 (2–80) | 92 ± 62.4 (3–245) | 32.6 | 23.8 | 22.1 | 21.0 | 0.5 |

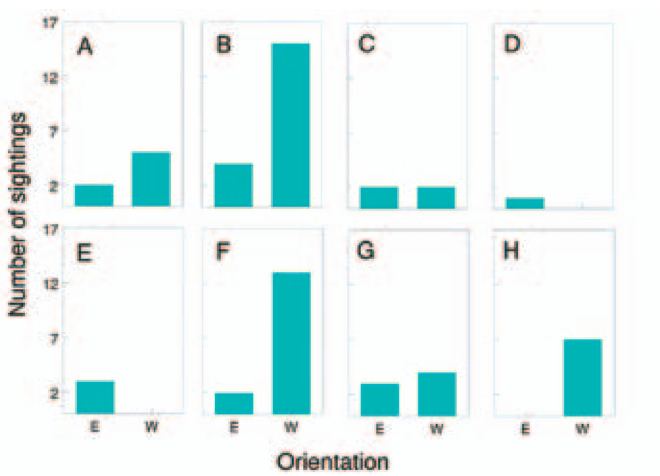


**Fig. 11.** Hatchling or adult iguanas found on eastern or western aspects according to time of day on Guana Island, BVI during 2009 sampling: (A) Hatchlings – early morning (before 1000 h); (B) Hatchlings – late morning (1001–1200 h); (C) Hatchlings – early afternoon (1201–1400 h); (D) Hatchlings – late afternoon (after 1401 h) (E) Adults – early morning; (F) Adults – late morning; (G) Adults – early afternoon; (H) Adults – late afternoon.

Significant differences existed in general slope and elevation among adult iguanas, hatchling iguanas, and random sites. A significant difference also was detected among adult iguanas, hatchling iguanas, and random sites when comparing general aspect. We found significant differences in aspect between hatchling and random sites and between adult and random sites, but not between hatchling and adult sites. Figure 10 illustrates the relationships between the number of iguanas encountered and aspect.

The number of iguanas sighted on easterly or westerly aspects in relation to time of day is illustrated in Fig. 11. The majority of iguana sightings (49%) occurred during late morning, and 44% of those iguanas were found on slopes facing southwest to northwest (225–314°).

## Discussion

The Stout Iguana has become successfully established on Guana Island since the translocation of eight individuals 25 years ago (Goodyear and Lazell 1994). Continued successful reproduction is evident in the numerous hatchlings encountered by researchers each year.

The distribution of iguanas throughout the island does not seem to be uniform. Iguanas appear to be in high densities on the western half of the island, particularly around developed areas, whereas they appear to be largely absent from eastern sections of the island.

Distribution also varied between adults and hatchlings. Hatchlings were typically in developed areas, whereas adults were found along both trails and in developed areas (Fig. 12). Some additional differences in habitat characteristics can likely be explained by preferred nesting locations. Stout Iguanas preferentially nest in sandy locations (Perry et al. 2007). Unlike Anegada, which is a low-lying island composed of limestone and sand, Guana is formed of igneous rock hills (to 246 m; Goodyear and Lazell 1994). Therefore, many

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**Fig. 12.** Both adult and hatchling iguanas were frequently encountered in areas with noticeable human activity or influence.

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**Fig. 13.** Stout Iguanas prefer to nest in sandy substrate. Beaches provide some of the best nesting habitat on Guana.

ROBERT POWELL

**Fig. 14.** Hatchling iguanas often remain near beaches; this unmarked individual thermoregulated by shuttling back and forth between sun and shade.

of the sandy areas suitable for nesting are along the beaches (Fig. 13). As iguanas on Guana are likely hatching near sea level, they may not have had enough time to disperse from their natal beaches to the higher elevations within the confines of the sampling periods (Fig. 14). This might explain the differences in elevations at which hatchlings and adults are encountered. Similarly, the areas nearest the beaches are generally flat, which might explain the differences between slopes at which age classes were encountered.

Differences in percentage canopy cover use between age classes may be a function of physiological constraints related to size. Smaller iguanas have a much higher surface area-to-volume ratio, and thus have less thermal inertia (Bell 1980). We suspect that the percentage canopy cover utilized by hatchlings is lower because of their need to actively thermoregulate more frequently. It might also explain why hatchlings were found more often in developed areas and the lowland flats. These areas appeared to be generally more open, whereas the trails are generally forested.

Finally, we believe that the feral sheep population is having a direct impact on this species. Although sheep eradication efforts have been in place since the 1980s and numbers have been reduced, reproduction still occurs. Sheep may outcompete iguanas by consuming much of the desirable understory vegetation within 2 m of ground level (Goodyear and Lazell 1994). Although not within the scope of this study, an apparent correlation between the presence of sheep — whether direct sightings of individuals or indirect evidence, such as tracks and scat — and the absence of iguanas was evident. Mitchell (1999) found that on Anegada, where feral livestock also is a problem, iguanas have altered their diets to include greater amounts of less palatable or even toxic leaves avoided by livestock. On Guana Island, iguanas may simply avoid areas overbrowsed by sheep, possibly explaining why none are encountered on the eastern side of the island.

Overall, the outlook for this species on Guana Island appears favorable. Not only has the species become established over the past 25 years, it seems to be flourishing. Still, long-term persistence of this population will depend on sound management strategies. These strategies should consider the fact that hatchlings and adults do differ in numerous habitat requirements. Removal of the feral sheep from the island would almost certainly be beneficial for iguanas. As protection for the Stout Iguana continues to be a contentious subject on the island of Anegada (Mitchell 2000, Perry and Gerber 2006), Guana Island currently represents this species' best chance for continued survival.

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