Herpetological Conservation and Biology 11(Monograph 6):79–89.
Submitted: 12 September 2014; Accepted: 12 November 2015; Published: 12 June 2016.

HABITAT UTILIZATION OF ROATÁN SPINY-TAILED IGUANAS (*CTENOSAURA OEDIRHINA*) AND ITS IMPLICATIONS FOR CONSERVATION

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Abstract.—**Resources available for *in situ* species conservation are limited. In order to make the most of what is available, habitats must be prioritized for protection. Biodiversity hotspots are one form of prioritization, e.g., identifying areas with many endemic species that are threatened by habitat loss. Within these larger areas, the habitats that make up the range of endemic species can also be prioritized in order to use limited conservation resources most effectively. With data gathered from use/availability surveys, resource selection functions can identify habitats and environmental variables associated with the presence of a species. Herein, we used these techniques to better understand the distribution of the Roatán Spiny-tailed Iguanas (*Ctenosaura oedirhina*), a narrow-range endemic on the island of Roatán, Honduras. Though certain environmental variables did influence the distribution of this species, our results indicate that protection from harvesting is the most important factor in determining their distribution across the island. In order to protect this species and insure its persistence in the wild, regulation and enforcement of harvesting practices must be applied, coupled with proper community education and outreach.**

Resumen.—**Los recursos disponibles para la conservación de especies *in situ* son limitados. Con el fin de obtener el máximo provecho de los recursos disponibles se deben priorizar los hábitats para su protección. Los centros de biodiversidad son una forma de priorización, donde se identifican áreas con una gran cantidad especies endémicas que están amenazadas por la pérdida de hábitat. Dentro de estas áreas de gran tamaño, los hábitats que contienen la mayor gama de especies endémicas pueden ser priorizadas con el fin de utilizar los recursos limitados en una manera más eficiente. Con los datos obtenidos de los sondeos de uso/disponibilidad, se pueden utilizar funciones de selección de recursos para identificar los hábitats y las variables ambientales asociados con la presencia de una especie. Aquí, hemos utilizado estas técnicas con el fin de entender mejor la distribución de las iguanas de cola espinosa de Roatán (*Ctenosaura oedirhina*), una especie endémica de rango limitado a la isla de Roatán, Honduras. Aunque ciertas variables ambientales an influido en la distribución de esta especie, nuestros resultados indican que la intensidad de caza es el factor más importante que determina su distribución en toda la isla. La regulación y la implementación de políticas adecuadas para control de la cacería deben ser aplicadas, junto con una educación comunitaria adecuada, con el fin de proteger a esta especie y asegurar su sobrevivencia en su estado silvestre.**

Key Words.—biodiversity hotspot; endemic species; habitat prioritization; habitat usage; hunting pressure; resource selection functions

INTRODUCTION

Prioritization of habitat protection is an important aspect of *in situ* species conservation. This is especially true when dealing with limited resources, as is often the case in conservation (Murdoch et al. 2007; Bottrill et al. 2008). Biodiversity hotspots are areas of high diversity that may be undergoing severe habitat degradation. These hotspots harbor high numbers of endemic species within small areas, such that the conservation of these areas protects a large proportion of global biodiversity (Myers et al. 2000). This same concept can be applied to smaller scale situations, such as the range of a single threatened species. Not all habitats are equal in their value to a species and some taxa may use habitat disproportionately to its availability. Species can actively select for a certain attribute, such as vegetation type or distance to water, or modify their niche preference based on dietary needs, thermoregulation, competition, and/or predation (Manly et al. 1992). In turn, conservationists can prioritize habitats for protection by identifying the environmental variables a species selects (Boyce and MacDonald 1999).

Use/availability surveys are used to determine what habitat a species uses and is able to access. These data can then be used to describe the habitat, or habitat variables, a species utilizes within a landscape (i.e., Resource Selection Functions (RSFs); Boyce and

Goode, Ashley B.C., Stesha A. Pasachnik, and Terry L. Maple. 2016. Habitat utilization of Roatán Spiny-tailed Iguanas (*Ctenosaura oedirhina*) and its implications for conservation. Pp. 79–89 *In* Iguanas: Biology, Systematics, and Conservation. Iverson, J.B., T.D. Grant, C.R. Knapp, and S.A. Pasachnik (Eds.). Herpetological Conservation and Biology 11(Monograph 6).

MacDonald 1999). Many studies use RSFs to focus resources for conservation initiatives. For example, using these methods Smith et al. (2004) found that current pastoral management techniques of the European Hare (*Lepus europeaus*) were not in fact helping to increase the hare population because the hares were selecting for different habitats than previously assumed. Changing management practices to increase heterogeneous pastoral habitat is thus more efficient for the farmers and also benefits the hares and the biodiversity of the region (Smith et al. 2004). RSFs can also be used to map currently and historically used habitat, which sometimes results in locating useful study sites and identifying possible reintroduction locations. Cleve et al. (2011) showed that the environmental variables used to predict habitat likely to contain the threatened Sierra Nevada Red Fox (*Vulpes vulpes necator*) successfully predicted an area that housed a new, previously unknown population. Naves et al. (2003) used resource modeling via logistic regression to outline the possible historic range of the Brown Bear (*Ursus arctos*) in Europe. These data could one day be used to repatriate individuals into previously inhabited areas.

RSFs and use/availability studies can also be used to develop maps of habitats that are worth delineating for official protection or for use in land management decisions. Chetkiewicz and Boyce (2009) used RSFs to identify habitat corridors for Grizzly Bears (*Ursus arctos*) and Mountain Lion (*Puma concolor*). These RSF data can then be used in future land management and planning (Chetkiewicz and Boyce 2009). Likewise, Smith et al. (2014), employing use/availability and habitat selection models, found that Greater Sage-grouse (*Centrocercus urophasianus*) selected against anthropogenically disturbed habitats and suggested that land managers prioritize distinct subunits of sage-grouse habitat when planning new development. When debating land planning and management, this type of information could be the difference between a species persisting in an area or being extirpated.

In this study, we employed use/availability surveys to develop RSFs which identify critical habitat for an endangered, narrow-range endemic iguana. Roatán Spiny-tailed Iguanas (*Ctenosaura oedirhina*) are found only on the 146 km^2 island of Roatán, ~ 50 km off the northern coast of Honduras (Fig. 1). Habitat destruction and fragmentation, the introduction of exotic species, and over-harvesting for consumption threaten this species (Pasachnik et al. 2015). Described in 1987 (de Queiroz), the Honduran government acknowledged this species as in need of protection in 1994 (Wilson and McCranie 2004), the IUCN listed them as Endangered on the Red List of Threatened Species in 2004, and they were included in Appendix II of CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) in 2010 (Pasachnik and Ariano 2010). Since its description, only larger-scale genetic and taxonomic studies have been conducted on this species (Kohler et al. 2000; Pasachnik et al. 2010) until recently (Pasachnik 2013; Pasachnik and Hudman this volume).

While it is officially illegal to hunt *C. oedirhina*, there is little to no enforcement on the island, and individual iguanas are regularly taken for food. In addition, there are legally protected areas and habitats (e.g., national parks), but the protection of these areas is not enforced. The growing tourism industry on the island heightens cause for concern. In less than 20 years, the urban area on the island increased from 1.8 km^2 in 1985 to 17.1 km^2 in 2001 (Aiello 2007) and over one million tourists visit the island a year (Doiron and Weissenberger 2014). Not only does this result in habitat destruction, but also an influx in people from the mainland arriving in hopes of finding jobs. This in turn increases hunting pressure on the local wildlife, particularly iguanas, as many recent immigrants are not able to find work and it is a custom on the mainland to consume iguanas (Fitch et al. 1982; Pasachnik et al. 2014). With no recognized protection for this iguana or other threatened species, protection through local grassroots efforts, such as localized hunting prohibition, is all that exists. This grassroots movement, which consists of private landowners, resorts, and tourist parks, has limited resources so the effort put forth must be used to the greatest effect.

Habitat utilization is an important ecological aspect that has direct implications for conservation. RSFs estimate the habitat usage and preference for specific resources for a given species. It is important not only to protect where the animals spend most of their time (i.e., their typical home range) but also the habitat(s) that they may use for just a small yet vital portion of the year (e.g., nest sites). It is also important to realize that both sexes have core areas of use within their home ranges and that these may change in size or location due to breeding or other seasonal factors. Thus, the protection of many habitat types may be necessary to support a given species. The objective of this study was to survey the habitat and environmental variables across the island of Roatán in order to determine those characteristics that define the preferred habitat of *Ctenosaura oedirhina*. Since so little land is actually protected for this species, it is imperative that the most utilized habitats be incorporated.

Methods and Materials

We collected data over a two-year period, during spring (April–May, 2012 and 2013), fall (August, 2012 and 2013), and winter (November–December 2012) on Roatán, Islas de la Bahia, Honduras (Fig. 1). We focused on two main seasons, the rainy season (September–January) and the dry season (February–August). Breeding and nesting occur in March–June and hatching in early August, after a 70–100 day incubation period (Pasachnik 2013).

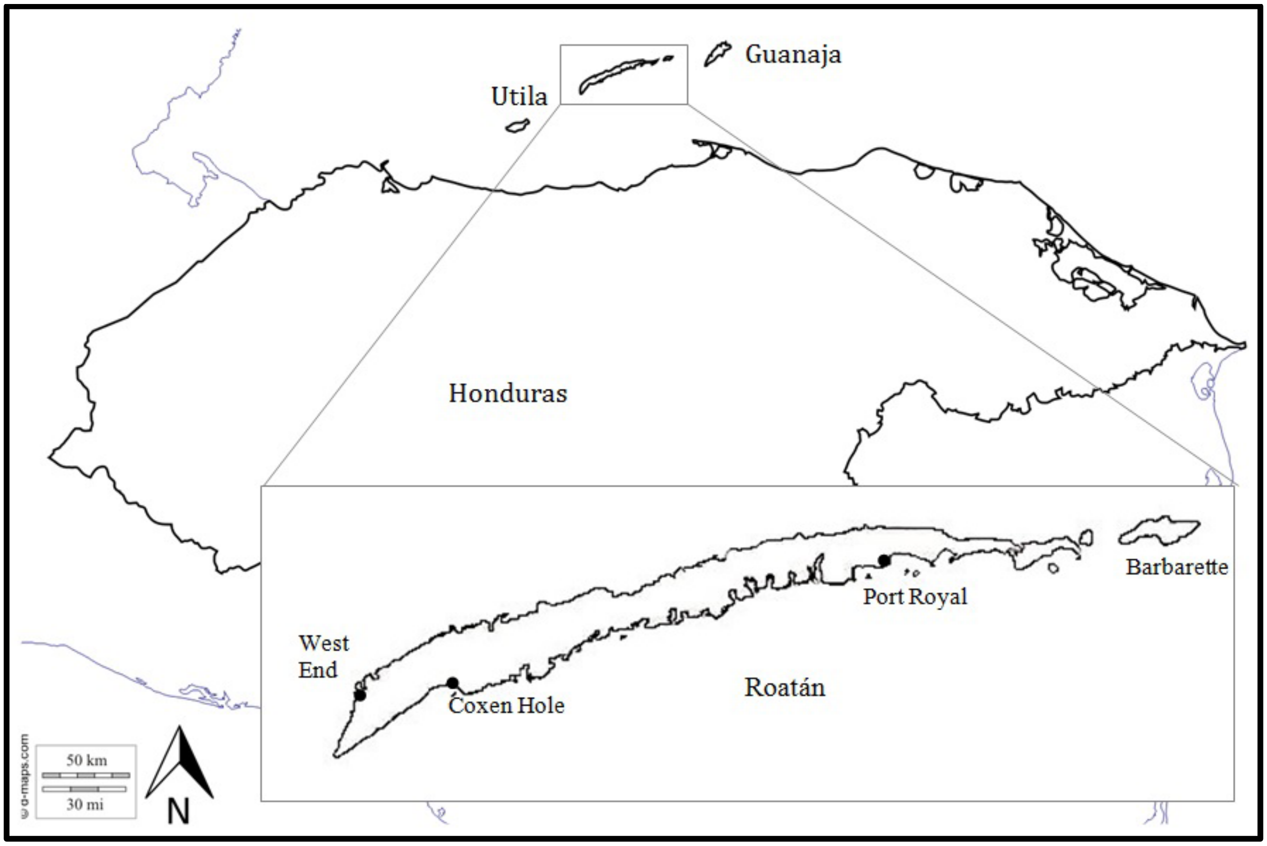

FIGURE 1. Map of Honduras and the Bay Islands, highlighting the study island, Roatán. D-maps.com. 2014. Map of Honduras (boundaries). Available from http://d-maps.com/pays.php?num_pay=146&lang=en [Accessed 25 August 2014].

Study location.—Roatán is covered primarily in seasonally dry tropical forest. The coastline is either white sand, rocky, or mangrove forest. Smaller islands and cays surround the main island of Roatán, some of which harbor iguanas. Barbareta is the largest (~ 5 km^2) of these and is located off the east end of Roatán. It is privately owned, and we could not obtain permission to survey it during our timeframe. Therefore, it has been excluded from our analyses. Because of the endangered status of this species, specific information about research sites is available only upon justifiable request.

Data collection.—We used Google Earth to map and calculate the area of available habitats on the island down to 100 m^2 sections. The latest available satellite photos (2013–2014) were used with data from Scripps Institute of Oceanography, National Oceanic and Atmospheric Association, U.S. Navy, National Geospatial-Intelligence Agency, and General Bathymetric Chart of the Oceans (Map data: Google, TerraMetrics). We ground-truthed all areas where the habitat classification was questionable. Since reliable satellite imagery is unavailable for the island for long-term habitat change analysis, we used ground cover data from Aiello (2007) and Programa REDD/CCAD-GIZ (2014) to make relative comparisons. As the Programa REDD/CCAD-GIZ (2014) work was not available during the design of this study, our habitat definitions vary slightly and thus direct comparisons are difficult (see below for additional details).

We conducted use/availability surveys along line transects located at nine study sites. To sample all of the available habitat types we non-randomly distributed transect locations across the island. Each transect was ~ 100 m long (range 90–110 m), and each location had at least three transects, for a total of 50 transects. We included both natural and altered landscapes, ranging from undisturbed to heavily disturbed, in our habitat surveys. We conducted surveys on multiple days between 0800 and 1500 during May (2013, 11 days), June (2013, two days), August (2012, 11 days; 2013, four days), November (2012, 11 days) and December (2012, one day). Due to logistics, trips were of varying lengths. Each site was surveyed during each season: spring (May–June), summer (August), and winter (November–December). While not all sites were surveyed an equal number of times, all were surveyed at least twice during each season. During each survey, at least one of us walked each transect and noted every iguana sighted on or along it, with its distance along and perpendicular

FIGURE 2. Representative examples of habitat types on Roatán. (A) Shore; (B) "Cleaned" forest; (C) "Uncleaned" forest; (D) Mangroves; (E) Stripped land (strip); (F) Agricultural land; (G) Anthropogenic land (anthro); and (H) Rock cliff (cliff). See Appendix for more details. Photographs by Ashley Goode.

distance from the transect to the nearest meter. We considered these the "used" points, and noted a suite of environmental variables for each point (e.g., habitat type, substrate type, distance to water, and disturbance level; see Fig. 2 and Appendix for details). We used a random number generator to select points along the transect, which we surveyed for the same variables. We considered these the "available" points. We also used the location of "used" points along each transect to determine the density of iguanas at each location.

Data analysis.—To determine if any changes occurred over time in either used or available habitat, we used χ^2 tests of the percentage of each habitat at each location using the chisq.test function in the R software package (α = 0.05 throughout) (R Development Core Team, Vienna, Austria). To make the Google Earth data comparable to the data from Aiello (2007), we used only the areas of anthropogenic, forest ("cleaned" and "uncleaned" forest combined, see Appendix for definitions), and sandy shore habitats in our analysis. Unfortunately, the Programa REDD/CCAD-GIZ (2014) data was not available during the setup of this study and thus direct comparisons were not possible due to variations in habitat type descriptions (see below for more detail). We compared data between and among study sites using contingency tables (chisq.test function in the R software package). We compared data between the study sites and the island as a whole in the same way. We replicated simulated *P* values 100,000 times because of the prevalence of zeros and small numbers in the data set. To establish the usage of each habitat type, we performed a logistic regression on the "used" and "available" points (logreg function in SAS® software) to determine resource selection functions (SAS Institute Inc., Cary, North Carolina, USA). We then used Akaike Information Criterion (AIC) to determine the preferred model, i.e., the model that best balanced goodness of fit and complexity (Anderson et al. 1998). After testing the global model, following models were pared down by grouping variables by similar *P* values (i.e., *P* values were binned and then variables that fell within those bins were grouped together). We used the program Distance to determine the density of iguanas at each study site (Thomas et al. 2010). The program calculated the density of iguanas along each transect based on "used" points from the use/availability transects (i.e., the distance along the transect and perpendicular distance from the transect of each iguana).

RESULTS

From the areas calculated using Google Earth, mainly seasonally dry tropical forests (~ 77%), coastal mangrove stands (~ 7%), and urbanized areas (~ 14%) cover the island. The remainder is mostly agricultural (< 1%, either pasture land for cattle and horses, or stands of bananas) or stripped land (< 1%, mostly cleared for new development, but some for mining operations) (Table 1). Satellite images cannot distinguish "cleaned" versus "uncleaned" forest, so we grouped them together. We compared these data to Aiello's (2007) study, which reported data from 1985 and 2001, and to data from 2014, compiled by the Honduran government (Programa

TABLE 1. Total available habitat for *Ctenosaura oedirhina* on the island of Roatán, Honduras.

Habitat	Area (km^2)	Percent of Total
Forest	99.08	77.65
Urban	18.29	14.33
Mangrove	8.90	6.98
Sandy Shore	0.48	0.38
Agriculture	0.46	0.36
Rocky Shore	0.21	0.16
Stripped	0.17	0.14

TABLE 2. Change in percentage of habitat area over time on Roatán, Honduras. The 2013 data are from Google Earth, the 1985 and 2001 data are from Aiello (2007), the 2014 data are from the Honduran government (Programa REDD/CCAD-GIZ 2014). It should be noted that the government map used differing definitions for some habitat types and thus direct comparison is not always appropriate (see methods for additional clarification).

Habitat	1985	2001	2013	2014
Urban	0.95%	13.87%	14.50%	6.84%
Forest	95.77%	85.47%	85.12%	85.17%
Sand	3.28%	0.66%	0.38%	7.99%

REDD/CCAD-GIZ 2014). We determined that large reductions in forest and sandy habitats occurred, while urban area increased dramatically (Table 2) between Aiello's (2007) study and ours. However when we attempted to compare our data to the 2014 data (Programa REDD/CCAD-GIZ 2014), it was apparent that different definitions of each habitat type were used. While the percent of forest cover seemed to be comparable across years/studies, there were discrepancies in urban areas and sandy habitats. Like Aiello (2007) we classified villages as "urban" even if they were not "urbanized" with paved roads, as much of the island is not paved but still contains high population density centers. The 2014 (Programa REDD/CCAD-GIZ) data, however, had a narrower classification, only delineating densely populated, paved areas as urban. Likewise our study defined sandy habitat as sand substrate with little to no vegetation occurring predominately along the shoreline, whereas the 2014 (Programa REDD/CCAD-GIZ) data used only the presence of a sand substrate and lack of dense vegetation to define this type of habitat. This possibly led to areas that our study delineated as "stripped" habitat to be identified as "sandy" habitat on the 2014 map. Some degree of discrepancy may also be due to the Honduran government (Programa REDD/CCAD-GIZ 2014) having access to more detailed aerial/satellite images that are not available to public.

From our surveys we concluded that used and available habitats at the study sites did not vary significantly from those available on the island as a whole (100,000 replicates; $P = 1$ for all combinations); however, the habitat did vary significantly among the study sites (100,000 replicates; $P < 0.0001$). Some sites are predominantly anthropogenic habitat while others are exclusively "uncleaned" forest with little to no direct anthropogenic impact. Iguanas were found in all habitat types, but not at all of the surveyed sites. Only six of our nine study sites contained iguanas. While other native fauna (such as Roatán Island Agouti (*Dasyprocta ruatanica*)) was noted within the grassroots protected study sites, neither iguanas nor other native terrestrial vertebrates were seen during surveys at nationally protected locations.

The global model for the resource selection function used all seasonal data from 2012–2013 and contained all 25 variables (nine habitats, nine substrates, four distances to water, and three disturbance levels; Table 3; see Appendix for details on variables). The global model had the best AIC value. However, when using relatively large datasets, AIC tends to select models with too many variables (e.g., the global models) (Hastie et al. 2001). In our case we believe that the global model, while deemed "best" by AIC, is not ecologically significant so the next best model was used for all further analysis. The second-most supported model, based on the AIC value, included the habitat variables anthropogenic, stripped, "uncleaned" forest, and shore, as well as vegetation and substrate variables most optimal for thermoregulation (rock, concrete, and gravel). Coefficient estimates showed that shore, "uncleaned" forest, stripped, and undisturbed habitats were "avoided", while anthropogenic, vegetation, rock, gravel, and concrete substrates were "preferred" (Table 4).

TABLE 3. Resource selection models describing the preferred habitat used by *Ctenosaura oedirhina* across Roatán, Honduras, and are in order of AIC score. See Appendix for variable details.

Model	df	χ^2	AIC	ΔAIC
Global – all variables	25	533.7	3518.2	0
Shore, Unclean, Strip, Anthro, Rock, Veg, Undist, Conc, Gravel	9	524.1	3698.2	180.0
Shore, Unclean, Strip, Anthro, Rock, Veg, Undist	7	485.9	3743.9	45.7
Shore, Unclean, Strip, Anthro, Rock, Veg, Conc, Gravel, Clean, Cliff, Dirt	11	600.1	3768.8	24.9
Shore, Unclean, Strip, Anthro, Rock, Veg	6	540.7	3844.5	75.7
Rocky cliff, Rock, Sand, Shore, <50m water	5	395.0	4112.1	267.7
Anthropogenic, Heavy dist	2	187.7	4284.8	172.6
Cleaned, Low dist	2	7.4	4477.4	192.6
Null – intercept only	0	–	4480.7	3.3

Locations containing the highest densities of iguanas had significant differences in used versus available habitat between the seasons (mainly between spring and fall, less so in winter) (Table 5). Iguanas exist in the highest densities within grassroots protected areas (Table 6). These protected areas make up only ~ 0.6 km^2 of the island (less than 0.01% of the total area of the island). We found iguanas almost non-existent in areas unprotected by the grassroots movement, (densities of 0–5 iguanas per km^2).

DISCUSSION

With limited resources, conservationists need to understand the specific distribution of a species, be it based on suitable habitat or human disturbance, so that limited resources can have the greatest impact (Caughly and Gunn 1996). Animals often select habitats and habitat characteristics based on food abundance, thermoregulation, predation, and competition. In these cases, conservation of the species can start with protecting

TABLE 4. Resource Selection Function coefficient estimates. Positive coefficients indicate a "preference" for those habitat variables on Roatán, Honduras by *Ctenosaura oedirhina*, while negative coefficients indicate "avoidance".

Variable	Estimate
Shore	-0.227
Uncleaned Forest	-0.638
Stripped	-2.297
Anthropogenic	0.552
Rock Substrate	1.963
Vegetation Substrate	2.131
Undisturbed	-2.224
Concrete Substrate	0.808
Gravel Substrate	0.805

TABLE 5. Differences in used and available habitat by location and season, for *Ctenosaura oedirhina* across Roatán, Honduras. A significant *P* value indicates a preference for a specific habitat during that season, i.e., the iguanas were selecting for a habitat more so than the availability of that habitat would indicate. Only six of the nine locations contained iguanas, so only those results are listed here.

Location/ Season	χ^2	*P* value	Predominant Used Habitat Type	Predominant Available Habitat Type
1/Spring	256.9	0.003	Anthropogenic	Anthropogenic
1/Fall	308.8	0.005	Anthropogenic/"Cleaned" forest	"Cleaned" forest
1/Winter	250.0	0.001	Anthropogenic/"Cleaned" forest	"Cleaned" forest
2/Spring	154.1	0.042	Anthropogenic	"Uncleaned" forest/Anthropogenic
2/Fall	265.9	0.002	"Cleaned" forest	"Cleaned" forest/"Uncleaned" forest
2/Winter	84.4	0.060	Anthropogenic	"Cleaned" forest/"Uncleaned" forest
3/Spring	229.7	0.005	Anthropogenic	Anthropogenic
3/Fall	296.3	0.001	"Cleaned" forest	"Cleaned" forest
3/Winter	129.6	0.075	Mangroves	"Cleaned" forest/Anthropogenic
4/Spring	105.3	0.007	Anthropogenic	Anthropogenic
4/Fall	137.1	0.001	Anthropogenic	"Cleaned" forest/Anthropogenic
5/Spring	225.0	0.036	Rock cliff	Mangroves/"Uncleaned" forest
5/Fall	312.1	0.026	Rock cliff	Mangroves/"Uncleaned" forest
5/Winter	379.4	0.112	Rock cliff	Mangroves/"Cleaned" forest
6/Spring	25.0	0.050	"Cleaned" forest	"Cleaned" forest
6/Fall	18.6	0.251	"Cleaned" forest	"Cleaned" forest

TABLE 6. *Ctenosaura oedirhina* densities at each study location across Roatán, Honduras. Densities were calculated using the program Distance (Thomas et al. 2010) and extrapolated to km^2. The densities shown are not the actual population size at any location, as none of the study locations were more than 0.2 km^2.

Location	Grassroots Protection Status	Sightings	Calculated Density (iguanas/km^2)	Site Area (km^2)
1	Protected	275	7,504	0.115
2	Protected	72	2,513	0.293
3	Protected	150	2,688	0.100
4	Protected	19	2,439	0.004
5	Protected	179	5,288	0.096
6	Not Protected	2	1	0.670
7	Not Protected	1	1	0.130
8	Not Protected	0	0	0.100
9	Not Protected	0	0	5.320

specific habitats discerned by RSF or other similar means (Boyce and McDonald 1999). Our RSF model suggests that *C. oedirhina* selects habitats at least in part based on thermoregulation, selecting more often for rock, concrete, and gravel (i.e., substrates that heat up quickly in the sun and hold that heat for much of the day). *Ctenosaura oedirhina* also selects for altered habitats; however, many acres of altered habitat on the island contain almost no iguanas, suggesting that another factor is likely accounting for the observed distribution.

The RSF model chosen to describe the distribution of *C. oedirhina* contained a mix of both undisturbed (undisturbed habitat, "uncleaned" forest) and heavily disturbed habitats (stripped habitat, anthropogenic habitat, concrete, and gravel substrate), and indicated an avoidance of "uncleaned" forest, stripped, and undisturbed habitat (Table 4). "Uncleaned" forest, stripped land, and undisturbed habitat have one very important thing in common: they are usually areas that are accessible to hunters. "Uncleaned", undisturbed areas, such as Port Royal National Park, offer little protection for wildlife against poachers as the area is not fenced or guarded. These locations look pristine, but appear to lack most of the native fauna that should accompany such habitats, based on our observations. Stripped land is available near many of the urban areas on the island, and is an effect of the developing tourist industry. Construction crews working in these locations have been observed by authors SAP and ABCG to hunt iguanas. In one instance, a home construction crew eliminated all of the iguanas within a previously densely populated area in a matter of months. The shore habitat is also "avoided" based on the model parameters (Table 4), but from our camera trap data, we know that iguanas use the shore early in the morning for very short amounts of time (3–5 minutes) to warm up, and then do not return there for the rest of the day. The shore typically does not offer refuge from the sun or hunters, and the sand also remains hot all day.

It is interesting that the selected model, discussed above, demonstrates that iguanas prefer anthropogenic habitat, considering the usual perils there, such as increased hunting pressure or domestic dogs and cats. However, on Roatán, iguanas are also afforded protection from hunting in many of the anthropogenic areas. Based on our model, we should find iguanas over a much wider area considering that the variables in the model account for over 15% of the island's area. However, less than 30 years after the description of this species (de Queiroz 1987) we find iguanas in stable densities on less than 1% of the island.

Hunting pressure has been shown to alter the distribution of a species (e.g., Madsen 1998; Grignolio et al. 2011; Imong 2013). Humans have likely hunted *C. oedirhina* for subsistence since they colonized the island approximately four thousand years ago (Fitch et al. 1982). The increase in human population and the onset of tourism on the island, however, has put an accelerated strain on the iguana population. Both local residents and curious tourists consume the iguanas, and recently the threat of poaching for the illegal pet trade has become more serious (Pasachnik and Ariano 2010). With over one million people visiting the island each year (Doiron and Weissenberger 2014), the iguana population simply will not be able to withstand the pressure from these growing threats. Although forests (seasonally dry tropical forest and mangroves) cover most of the island, the increase in urban area is substantial and observable even over the two years of this study. Much of the island is still pristine forest, but hunting pressure has caused these areas to be nearly devoid of vertebrate life. High densities of iguanas occur only in sites where grassroots efforts prohibit hunting, even though the sites themselves are generally small, from 0.008 km^2 (approximately two acres) to 0.25 km^2, and are quite disturbed. The iguanas are almost non-existent outside of these areas, even in comparable or more pristine habitat.

It should be noted, however, that iguana density reflects habitat usage, but not necessarily individual health. Pasachnik (2013) showed that body condition index (BCI) is highest in the sites with the greatest anthropogenic influence, but an unhealthy diet of scavenged fatty human food could account for this (see Smith and Iverson this volume). Additional research is needed in order to better understand this facet, as well as whether or not stress is induced by daily interactions with humans (e.g., Knapp et al. 2013). This will then elucidate the health of these dense populations, and in turn the overall stability of this species.

Hunting pressure is an important factor determining habitat usage for many species (Imong et al. 2013; Stoner et al. 2013). While some aspects of the habitat (e.g., shore, rock, gravel) of *C. oedirhina* are selected for more than others, the decisive factor in determining whether or not iguanas occupy a site is the degree of protection it affords. This has important implications for conservation efforts. The management and grassroots protection of specific sites is currently very unstable. If the ownership or management of any one of the sites changes, one of these businesses closes, or a private resident moves, it could easily result in the local extirpation of this species. Instead of attempting to protect specific habitats, our results suggest that enforcing protection of the iguanas themselves should be most effective. To achieve this, however, a strong outreach and education campaign involving all stakeholders will be necessary. Many people living on the island are unaware or choose to ignore the endangered status of this species, and the fact that it is distinct from the sympatric Green Iguana (*Iguana iguana*) and other species of ctenosaurs that inhabit the mainland and neighboring islands.

We note that the consumption of iguana meat is of some cultural importance to the people of Roatán, and does provide an important protein source for some people. We thus suggest management approaches that ensure the persistence of this and other endemic species on the island alongside the preservation of cultural traditions and dietary demands. The development of a national conservation plan for this species with the cooperation and input of all stakeholders, including island residents and business owners, local authorities, non-governmental organizations (NGOs), governmental agencies, and scientists is the first step in increasing awareness and ensuring long-term commitments from all parties. Such a plan must consist of actions that guarantee the enforcement of the existing laws occurs, while modifying these laws to consider the needs of the local community. Enacting and enforcing a hunting season in a restricted area is one option. Another option is to work toward refocusing hunting efforts on similar but non-threatened species. Green Iguanas are native to the island but not Endangered. They are already being consumed to some degree, so farming them or purchasing them from mainland farms may be feasible. These actions should not be taken lightly and a strong education component must be incorporated. Accompanying these efforts, managers might also consider a captive breeding program for *Ctenosaura oedirhina*, with the necessary habitat protection enforced by the government, including local law enforcement agencies. Our results clearly show the generalist nature of this species, thus a reintroduction program is very feasible as long as habitat protection can be assured and hunting can be regulated or prevented.

Acknowledgments.—We would like to thank Mikel Belcaries, Henry Montalvan, and Joseph Anderson for field assistance, and Dale Gawlik and Erik Noonburg for their assistance with the statistical analysis. This project would not have been possible without the generosity of the International Iguana Foundation, Mohamed bin Zayed Species Conservation Fund, Phoenix Zoo, Riverbanks Zoo and Gardens, San Diego Zoo Institute for Conservation Research (providing salary for SAP), and our in-country support Andrea Martinez and the Kanahua Utila Research and Conservation Facility. This study was approved by the Florida Atlantic University International Animal Care and Use Committee (Protocol A12-06) and the Honduran Government (Honduran Conservation Permit DVS-ICF-054-2010). Our work was also supported by the National Science Foundation under NSF Grant No. DGE: 0638662. Our conclusions or recommendations do not necessarily reflect the views of the NSF.

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Appendix. Environmental variables used in the Resource Selection Functions (RSFs) to describe the habitat accessible to *Ctenosaura oedirhina* across Roatán, Honduras.

Habitat type.—The general habitat types found across Roatán include: shore, "cleaned" forest, "uncleaned" forest, mangroves, stripped land (strip), agricultural land, anthropogenic land (anthro), water, and rock cliff (cliff) (Fig. 2).

Shore	Consists of sandy beach habitat along a salt body of water. Shore is naturally narrow (< 5 m) on the island, but humans have altered it in some areas to be wider for tourism. Shore has a sand substrate, but often there is washed-up vegetation from the ocean and occasionally live vegetation (*Ipomoea* spp.) growing low on the ground.
Forest	Consists primarily of seasonally dry tropical forest (Pennington and Ratter 2010). Canopies of Gumbo-limbo (*Bursera simaruba*), Dogwood (*Piscidia piscipula*), Hog Plum (*Spondias mombin*), and Bullhorn Acacia (*Vachellia cornigera*) are commonly found, some reaching heights of 10–20 m. The understory includes Palmettos (*Sabal* spp.), Wild Grape (*Vitis* spp.), and perennial grasses when an understory is still present. "Cleaned" forests are areas cleaned of their understory, often around houses and businesses. "Uncleaned" forests have an intact understory that is often very dense.
Mangrove	Consists of mainly Red Mangroves, but sometimes also contains White and Black Mangroves. This habitat often has standing salt or brackish water for most of the year; usually shallow (< 0.5 m).
Stripped land	Consists of land stripped of all vegetation down to a sand, dirt, or gravel substrate. This is usually done in preparation for development or mining operations.
Agricultural land	Consists of land primarily being used to graze livestock (cattle or horses) or grow crops (mainly bananas).
Anthropogenic	Land consisting of landscaped areas, usually around residences or in parks, and urban areas.
Water	Habitat consisting of any open water, fresh or salt.
Rock cliff	Habitat consisting of cliffs 5–15 m high along a marine body of water. Cliffs have sheer faces or are boulder strewn, with some boulders measuring 1–2 m across.

Substrate type.—The substrates within the habitat type consist of rock, dirt, sand, mulch, grass, other vegetation (veg), gravel, water, and concrete (conc).

Distance from water (salt or fresh).—Distance from water is measured in four levels – 0 (in water), < 50 m, 50–100 m, > 100 m.

Anthropogenic effects.—Anthropogenic effects were divided into three levels: undisturbed (undist), lightly disturbed (light dist), and heavily disturbed (heavy dist).

Undisturbed	Areas consisting of undeveloped land with no human residents or livestock. There were no streets, buildings, or other infrastructure except for hand-cut walking trails.
Lightly disturbed	Areas that have some development or infrastructure, but not significant amounts, and there is no landscaping. These areas had natural vegetation and low human or livestock populations.
Heavily disturbed	Areas that have been significantly altered by humans. This consists of urbanized districts: streets, buildings, or large-scale landscaping, and high human or livestock populations were found in these areas.

Seasonality.—Data were also divided by season: (1) spring (April–May); (2) summer (August); and winter (November–December).