Rotem Zilber, University College Utrecht

At 07:30 in the morning, when dragonflies still dominate the air, and the silent soaring of the Crested Caracara greet me, I start my day. The Conew have long gone to sleep, and the land remains quiet save for the Trupial and Bananaquit's morning birdsong, I begin my quest to find the elusive Cascabel. Notoriously difficult to find, I am not aided by its quiet nature and remarkable camouflage. As the morning progresses, the first restless movement of Cododo embarking on a new day can be heard, and I find myself experiencing nature as a great beast uncurling and waking up for another cycle of life. Within minutes, an endless stream of movement can be heard, as the lizards soak up the sun and forage for food, and I begin making transects to analyze their distribution and how they utilize their habitat. When I take a moment to rest, a Toteki stares down at me from a tree branch, while the chirping of geckos is faintly discernible nearby, punctuated by the hooting of an owl defending its burrow. After noting their presence, I continue to look for more of their brethren. Some might call this work, but for me, it is a connection to nature far deeper than any textbook can describe.

By finding these species in areas proposed for conservation, I can aid in increasing their importance to become Key Biodiversity Areas. On Aruba, Park Arikok and the Spaans Lagoon are already a haven for locally endemic fauna, vulnerable due to their limited range. The conservation of species and the management of allotted land is a long process. Although sometimes the problems encountered seem insurmountable, I see my work as part of a puzzle. If we each contribute our piece, together our work will fit together to find a solution.

I want to help make a difference in their survival, and it is for this reason, that I chose to work on assessing future conservation areas for these species.

I would like to thank Robert Kock from the Directorate of Nature and Environment for his assistance in fine tuning my project, his ongoing support, and in giving me an opportunity to help. I would also like to thank Natasha Silva and Aldrick Besaril from Park Arikok, for teaching me to find and recognize the Cascabel, and for showing me the potential outcome of conservation through the wild beauty of Aruba in Park Arikok. I would like to thank Kaylin Palm, my student assistant from the University of Aruba's Academic Foundation Year, for her dedication and hard work. Lastly, I would like to thank my parents, for always believing in me and supporting my dreams.

Assessment of Endemic Fauna in Key Biodiversity Areas in Aruba

by Rotem Zilber

Introduction

Long before the industrial revolution, *homo sapiens* held the record among all organisms for driving the most plant and animal species to their extinctions (Harari, 2014). However, the rate of biodiversity loss has recently reached a peak, with extinction rates enhanced to 1,000 time the rate of natural extinction. On the trajectory on which we are leading ourselves, a sixth mass extinction in Earth history appears inevitable.

Habitat destruction is one of the main factors driving these increased rates of species extinction. Species that remain abundant in the undisturbed fragments are often considered less threatened by their location. However, as land becomes more fragmented, it becomes prone to the 'delayed fallout effects'. This means that current habitat destruction will cause delayed extinction during future generations, creating an ecological debt that must be compensated for in order to return the ecosystem to equilibrium (Tillman et al., 1994). It is therefore important to identify patches of land that contain a high species count, in order to conserve them and inhibit threat from the delayed fallout effect. Furthermore, Macarthur and Wilson's theory of island biogeography suggests that a smaller fragment or island has a lower potential equilibrium for the number of species. This indicates that the more fragmented the land, the less biodiversity it can maintain in the long term.

Rockström et al.'s (2009) research on the planetary boundaries framework defines a safe operating space for humanity with respect to the Earth system. They suggest that the critical threshold of biodiversity loss from which Earth could recover has passed a tipping point from which there is a high risk of no return. Steffen et al. (2015) revised this framework by suggesting a two component approach for biosphere integrity. The first is the method used in Rockström et al.'s (2009) paper, by assessing the threshold of biodiversity using extinction as a control variable. Steffen et al. (2015) suggest that there is a risk in using this method as it does not account for phylogenetic and functional diversity, and it is unknown how much biodiversity loss Earth can withstand before change becomes irreversible. They suggest adding a second category, which assesses change in population abundance as a result of human impact on ecosystems, rather than on a global level, by comparing the current status of ecosystems to that of pre-industrial levels. By using Steffen et al.'s (2015) method, it could be possible to distinguish areas that remain mostly pristine, and therefore focus conservation efforts there.

Myers et al. (2000) have determined another method for locating conservation areas that could help maintain the highest possible degree of biodiversity, while

acknowledging a limited budget and space availability. This theory notably focuses on endemic species, which are the most restricted in range and consequently prone to extinction. A key factor in determining conservation areas is therefore the degree of endemism which presides in an ecosystem. Thus, Myers et al. (2000) conclude, the theory of hotspots, 'areas where exceptional concentrations of endemic species are undergoing exceptional loss of habitat' are areas that should be a focus for global conservation efforts. Myers et al.'s (2000) analysis of global hotspots is limited to the terrestrial realm, meaning that in the case of island hotspots, boundaries are naturally defined by the sea. It is of note that small islands in particular are already isolated lands, their size limiting the number of species that can survive in their state of equilibrium. In order to qualify as a global hotspot, a region must contain at least 0.5% of the world's plant species (1,500/300,000) in endemics. The Caribbean boasts one of the top five highest endemism to landmass ratio, containing 2.3% of the world's plants in terms of endemics, as well as 2.9% of vertebrates. One of the areas used to analyze the endemic diversity of the greater Caribbean hotspot is Aruba's national park, Park Arikok (BEST, 2016).

The Directorate of Nature and Environment (DNM) of Aruba was created in 2012 and is responsible for developing policies, conducting research, and enforcing legislation on nature and the environment (BEST, 2016). They have an ongoing project to increase nature conservation efforts beyond the national park. There are six categories under which chosen areas can fall: habitats of protected native species, habitats of species threatened worldwide, habitats of endemic species, habitats and ecosystems that have an important ecological role in the contributions and processes of conservation and continuation of the biodiversity, areas of ecological corridors between larger natural areas, and wetlands. The areas that meet any of these criteria are referred to as Key Biodiversity Areas (KBA), making them priority areas for action (BEST, 2016). The more categories a KBA falls under, the higher the prioritization becomes to legalize its conservation status. It is important to note that in order to be designated as a protected natural area, the area must be governmentally owned public property (ROP, 2009).

This project focused on gathering data on habitats of endemic species in five terrestrial KBA's (henceforth 'research area' or RA): California, Hooiberg, Sero Biento, Sero Canashito, Rooi Prikichi dam, by answering the research question '**What is the species richness, density, diversity, and evenness of Aruba's endemic fauna in top terrestrial Key Biodiversity Areas as proposed for conservation by the Directie Natuur en Milieu?**'. This was accomplished by answering the following sub questions: '**What are the endemic fauna species of Aruba, what do they look like, what is their known habitat utilization?', 'What is the optimal way to accomplish field observations?', 'What are the characteristics of the RAs?', 'What are the species distribution and density within the research areas?', and 'How does the species richness, density, diversity, and evenness compare between the research areas?'.**

Materials and Methods

In order to identify the endemic fauna species of Aruba, their characteristics, and their habitat utilization, a literary survey was conducted. The species surveyed were: Aruban Whiptail Lizard (*Cnemidophorus lemniscatus arubensis)*, Striped Anole (*Anolis lineatus)*, Aruban Leaf-toed Gecko (*Phyllodactylus julieni)*, Aruba Island Rattlesnake (*Crotalus durissus unicolor)*, Aruban Cottontail Rabbit (*Sylvilagus floridanus nigronuchalis)*, Aruban Burrowing Owl (*Athene cunicularia arubensis)*, and the Brown-throated Parakeet (*Aratinga pertinax arubensis*) (DCNA, 2014). An identification sheet of photographs of each species was created, including pictures of both male and female individuals for the dimorphic species.

Preliminary visits to the RAs were conducted in order to acquaint with the habitats, learn to identify the species in the field, as well as to test which methodology proved most adaptable to the range of habitats and species. The Aruba island rattlesnake were specifically studied within Park Arikok with the assistance of a park ranger, due to their venomous nature and particular habitat requirements. Additionally, attempts were made to spot the nocturnal species, the Aruban Cottontail rabbit where their prints were found, and the Aruba leaf-toed gecko in what is considered optimal gecko habitat, at night. For the Aruba Cottontail rabbit, no live specimens were seen during the day nor night, therefore it was determined that research during the night was not necessary. As for the Aruban leaf-toed gecko, individuals were seen during the day, and none were found at night, thus further attempts at night surveys were discarded. Data on detailed daily activity was found for two species, the Aruban island rattlesnake and the Aruban whiptail lizard. The peak activity of the Aruban island rattlesnake is between 07:00-09:00 and 17:00-sundown (Reinert et al., 2002), however the snake can be found in the open in shaded areas thereafter. The optimal time for the Aruban whiptail lizard is between 10:00-12:00am. After a number of field observations, it was noted that only for finding this species was time crucial, therefore the time frame during which data was collected was adjusted accordingly to 09:30am-13:00pm.

Pilot investigations in the research areas put an emphasis on finding a method that would be suitable to study not only different habitats, but species that utilize them in different manners. The method that proved most suitable to study the species distribution and density within the research areas was through the use of transects. Standardization was necessary in order to later compare the RAs through extrapolation of the findings. It was therefore met by studying 10% of each RA. For this, RA boundaries were identified using the computer application Google Earth Pro (2016), after which the area of each RA was calculated. Boundaries were determined for the RAs by accounting for the fragmentation of the land. The three hills Hooiberg, Sero Canashito, and Sero Biento, are completely isolated by roads and houses, therefore these were taken as reference for boundaries. California is bound by the sea and a golf course on two sides, and on the other two the California dunes and the Tierra del sol Salina. The only unfragmented area, Rooi Prikichi Dam, was determined as sketched on a map by the DNM.

Each transect incorporated species within two meters on either side of the researcher. The targeted length of transects was determined by calculating 10% of the research area, and dividing it by the 4 meters width of the transect. In order to determine the degree of error permitted in transect length, 10% of the targeted transect length was calculated by dividing the transect length by 10. An indication that standardization was met was determined by assessing the correlation between the number of individuals, the time spent per transect, and the transect length. No correlation was found between these factors, thus it was concluded that this approach was valid.

Data collection was accomplished using the 'Geo Tracker' application on a BLU Studio Smartphone. It indicates the travel route, distance, time, and elevation of any given point on the route, as well as allowing to add pin markers throughout the walk and calculating final statistics of average speed. The tracker was turned on at the starting point of analysis, after which each relevant species was noted using pin markers on the app. At the end of each transect the application was stopped, and the datasets were uploaded to Google Earth Pro. To achieve the best distribution of transects throughout the different habitats within the RA, opposite sides were analyzed. In some cases, the area appears analyzed in a less evenly distributed manner, as the vegetation either became too dense or the land too steep to continue safely. In order to identify the dominant flora during fieldwork, the guide book 'Arnoldo's

Zakflora' (2012) was used. Characteristics of the RAs were determined by conducting a literary survey on each area's elevation (Google Earth), substrate, and historical land use (Derix, 2016), as well as field observations.

The collected data was analyzed by plotting all the transects onto the RA maps, and by adding pins at the coordinates where each individual of each species was found. The number of each individual along each transect was counted, and the sum of each RA determined. Studies on the Aruban cottontail rabbit's closest relative on the American continent revealed that they live a solitary life, even though they may be found in proximity to each other (Trent and Rongstad, 1974). Thus, each set of prints was considered one rabbit.

In order to determine species richness, diversity and evenness, Table 3 was made to incorporate the final species count for each RA. Subsequently, species richness was determined by calculating the number of species present in each RA. A graph (Figure 1) was then created to test whether the number of individuals per area grows with RA size. determine if a relationship exists between the size of the RA and the number of species present. Under MacArthur and Wilson's theory of island biogeography, it is expected that the larger the area, the higher the potential equilibrium number of species. This additionally means that in larger patches, there is more space available for more individuals of each species. The species richness was then inserted in the Shannon-Weaver Index (H) for calculating species diversity, using the equation (), where p_i is the proportion of species *i,* relative to the total number of individuals of all species present. This is then multiplied by the natural logarithm of the same p_i. This is done for each species, and the sum of all multiplied by (-1) (M. Beals, 2000). Although the Shannon-Weaver Index accounts for species evenness, the index tends to yield a higher result with increasing number of species. Therefore, species evenness was calculated using the Pielou Index (J). This was based on the results of the Shannon-Weaver Index, with the equation (), where *H'* is the result of the Shannon-Weaver Index, which is divided by the natural logarithm of *S*, the number of species present in the area (Aho, n.d.). Finally, a comparison between the RAs was drawn using the results, and their order of suitability as conservation areas for endemic species determined.

Results

Table 1 gives an overview of the endemic fauna species of Aruba, what they look like, and what is known about their preferred habitat. The field identification sheet that was created included the name and pictures of each species, and in cases of dimorphism, of both male and female individuals. Table 2 gives an overview of the information calculated and gathered on the research areas, their elevation and substrate, as well as the results for the calculated area, transect length, margin of error for transect length, and accomplished transect length. Dominant vegetation as observed during fieldwork is presented. Lastly, observations made during fieldwork and anthropogenic use of the RAs is explained. As can be seen in the table under 'accomplished transects', additional transects need to be accomplished in the areas of California and Hooiberg in order to complete the standardized 10% of the RA.

The number of individuals of each species as found in the RAs, and the results of the calculations for species richness, density, evenness, and subsequent RA ranking, can be viewed in Table 3. Figure 1 is a graph that shows the number of individuals of all species by plotting the number of individuals per RA area$^{0.25}$. The resulting trendline shows an R^2 value of 0.86, meaning that there is a positive correlation that the smaller the size of the RA the higher the number of individuals present. Figures 2-6 depict maps of the RAs, showing the transects accomplished, as well as the location of where each individual of the species were found.

Species Profile				
Species				**Identification** (IUCN)
Latin	**English**	**Papiamento**	**Dutch**	
Cnemidophorus lemniscatus arubensis	Aruban Whiptail Lizard	Cododo	Arubaans Renhagedis	Hummelinck, 1940
Anolis lineatus	Striped Anole	Toteki (Aruba), Waltaca (Curacao)	Gestreepte Boomhagedis	Daudin, 1802
Phyllodactylus julieni	Aruba Leaf-toed Gecko	Arubaans pegapega	Gekko	Cope, 1885
Crotalus durissus unicolor	Aruba sland rattlesnake	Cascabel	Arubaans Ratelslang	Van Lidth de Jeude, 1887
Sylvilagus floridanus nigronuchalis	Arubian Cottontail rabbit	Conew	Arubaans Katoenstaart Konijn	Hartert, 1894
Athene cunicularia arubensis	Aruban burrowing owl	Shoco	Holenuil	Cory, 1915
Aratinga pertinax arubensis	Brown-throated parakeet	Prikichi	Maisparkiet	Hartert, 1891

Species Profile		
Habitat	**Description**	**Comments**
Reptiles		
Endemic to Aruba. Abundant in differing densities island wide. Optimal habitat is flat terrain with deep sandy soil, plentiful vegetation, shrubs with a large basal or stem area, a large shrub-open area margin, and a complex temperature profile (Schall, 1974).	Breeding males are characterized by a bright blue sheen. Non breeding males are equally large but have blue spots rather than a solid coloring. Females are brown with dark stripes and blue spots on their sides (Arikok FactSheet).	
Endemic to Aruba and Curacao. Mostly found on tree trunks and branches. Commonly on tree species such as *Acacia tortuosa* (Arikok FactSheet).	Both genders are different shades of greenish brown, with two black stripes along their sides (Arikok Fact sheet). Breeding males have a uniquely asymetrical bright orange dewlap with a black spot, and typical extendable dorsal crests upon their neck and back. Females are smaller in size and have a smaller dewlap of the same coloration (Gartner et al., 2013).	
Endemic to Aruba. *Phyllodactylus* genus are known to prefer arid to semi-arid habitats, where they live under tree bark and rock crevices (Dixon, 1962).	Clover leaf toes with white pads. Light brown with darker stripes.	
Endemic to Aruba. Limestone outcropts, with a primarily barren ground and shade in the form of trees and low bushes. Peak activity between 07:00-09:00, 17:00-sundown (Reinert et al., 2002). Outside these times, the snake remains in the open, in shaded areas.	Light brown to grey brown in coloring. Slightly darker diamond shapes on the back (Arikok FactSheet).	IUCN redlist (IUCN).
Mammals		
Endemic to Aruba and Curacao. Distributed almost island wide. Prefers lightly hilly ground with a quartz-diorite substrate, predominantly on the south and east sides of the hills, with availability of melocactus for food (Bekker, 1996).	Long ears with longer hind limbs than forelimbs. Grey brown fur on the back, white underbelly, tail, and ear margins. Black patch on the back of the neck (Bekker, 1996).	
Birds		
Endemic to Aruba. Denser distribution in urban areas. Require open space with substrate into which it can dig a burrow (Derix, Peterson, and Marquez, 2011).	Generally found as individuals or in pairs outside burrows, which they dig into the ground. Various shades of speckled brown. Small in stature with long legs. Males are slightly larger than females.	National symbol. Locally Endangered (DCNA, 2014).
Endemic to Aruba. Island wide. Commonly found solitary or in pairs, although they are known to for flocks of up to 100 individuals (Derix, Peterson, and Marquez, 2011).	Dominantly green colored parrot, with a brown throat, and yellow ring around the eyes. Their screetch is loud and easily identifiably.	National bird.

Table 1- Species profile- the endemic species of Aruba, their preferred habitat, and a description of each species.

Research Areas							
Research Area	**Maximum Elevation (m)** (GoogleMaps, 2016)	**Size (m^2)**	**Transect Length Aim (m)**	**Error Margin (m)**	**Transect Length Accomplished (m)**	**Substrate** (Derix, 2016)	**Identified Dominant Vegetation**
California	20	691,000	17,275	1,727.50	4,002	Limestone Reef, Alluvial Mud and Sand, Quartz Diorite	*Vachellia tortuosa, melocactus, weeds and grasses*
Hooiberg	165	239,000	5,975	597.5	5,039	Hooibergiet	*Cereus repandum, Stenocereus griseus, melocactus, acacia, Calotropis procera*
Sero Canashito	55	184,000	4,600	460	4,684	Hornblende Tonalite, Limestone Reef, Alluvial Mud and Sand	*Pithecellobium unguis-cati, Aloe vera*
Sero Biento	64	98,000	2,450	245	2,389	Hooibergiet, Hornblende Tonalite	*Cereus repandum, melocactus, agave*
Rooi Prikichi Dam	29	25,000	625	62.5	639	Hornblende Tonalite	*Cereus repandum, Stenocereus griseus, melocactus, opuntia caracassana (tuna), acacia, grasses*

Research Areas
Comments
The length of this area ranges from the California Dunes to Tierra del sol Salina along the north east coast of the island. The coast is rocky with fossilized coral shelves, which change to a barren sandy landscape with increasingly weedy vegetation and low bushes inland. The inland boundary of the area is recognized as the fence of the golf course, where the ground is increasingly hilly and dominated by a rocky substrate and turkshead cacti. Many a tourist and local visit this area for recreational purposes such as four-wheel drives, jeeps, motorcycles, jogging, and strolling.
The area is surrounded by road on all sides and is one of the highest peaks on Aruba. The hill is used for recreational purposes, and has a staircase leading to the top. There are numerous additional paths from humans and goats alike. The lower elevations appear more dense in vegetation. There are multiple antennas on the top of the hill from the telecommunication company Setar.
The base of the north west side of Canashito was used as an aloe vera farm in the early 1900's (Derix, 2016). This has affected the vegetation in the area, causing the north west side to appear as an overgrown garden, whereas the top, dominated by a reef terrace, remains barely vegetated. The south side of the hill is dominated by a dry forest of acacias and shrubs. The south west of the hill has been excavated for use by a building company, however remains abandoned. There is a paved road and a large portion of excavated land, with some abandoned structures and piles of building material. The north side additionally has a number of caves with Arawak cave paintings and bats. This area is bound by roads and the Canashito factory.
A low hill lying between Hooiberg and Sero Canashito, Sero Biento is not very densely vegetated in most areas. The base on the southwest side was historically used as an aloe vera plantation in the early 1900's. There remains an old house structure with a large overgrown garden (Derix, 2016). There are a numer of walking paths on the hill, and a deck on one of the peaks. This area is bound by roads on all sides.
A temporary lake lies in this area, where numerous rooien merge. It appears relatively untouched by humans, although it is easily accessible through the surrounding rooien. The study area was determined as roughly explained by the DNM.

Table 2- Research area profile- the research areas, their elevation, area, calculated transect length, margin of error for transect length, accomplished transect length, substrate, dominant vegetation, and general comments.

Species Density, Extrapolation, Richness, Diversity, and Evenness										
Area	**California**		**Hooiberg**		**Sero Canashito**		**Sero Biento**		**Rooi Prikichi Dam**	
Species (# of individuals)	**Total**	**Extrapolation**	**Total**	**Extrapolation**	**Total**	**Extrapolation**	**Total**	**Extrapolation**	**Total**	**Extrapolation**
Cnemidophorus lemniscatus arubensis	96	960	47	470	57	570	59	590	24	240
Anolis lineatus	0	0	0	0	6	60	0	0	0	0
Phyllodactylus julieni	0	0	0	0	0	0	0	0	2	20
Crotalus unicolor	0	0	0	0	0	0	0	0	0	0
Sylvilagus floridanus nigronuchalis	0	0	4	40	4	40	0	0	0	0
Athene cunicularia arubensis	3	30	2	20	2	20	0	0	0	0
Aratinga pertinax arubensis	0	0	0	0	2	20	0	0	0	0
Total	99	990	53	530	71	710	59	590	26	260
Species Richness	2/7		3/7		5/7		1/7		2/7	
Ranking	**3.5**		**2**		**1**		**5**		**3.5**	
Species Density (#ind/area)	0.001		0.002		0.004		0.006		0.01	
Ranking	**5**		**4**		**3**		**2**		**1**	
Species Diversity (H)	0.14		0.43		0.75		0.00		0.27	
Ranking	**4**		**2**		**1**		**5**		**3**	
Species Evenness (J)	0.2		0.39		0.47		0		0.39	
Ranking	**4**		**2.5**		**1**		**5**		**2.5**	

Table 3-The number of individuals of each species found in each RA, the extrapolation of this data, the results of the calculations, and the ranking for each area for species richness, density, diversity (Shannon-Weaver Index), and evenness (Pielou Index).

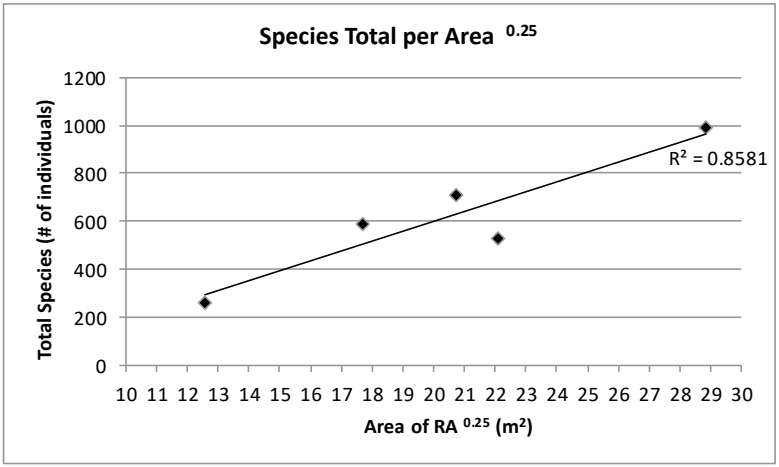

Figure 1

Figure 1- Graph of the number of individuals of all species observed in each RA in relation to its size$^{0.25}$.

Figure 2

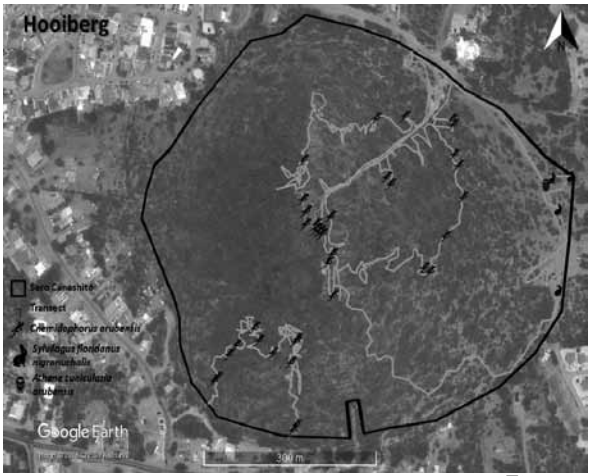

Figure 3

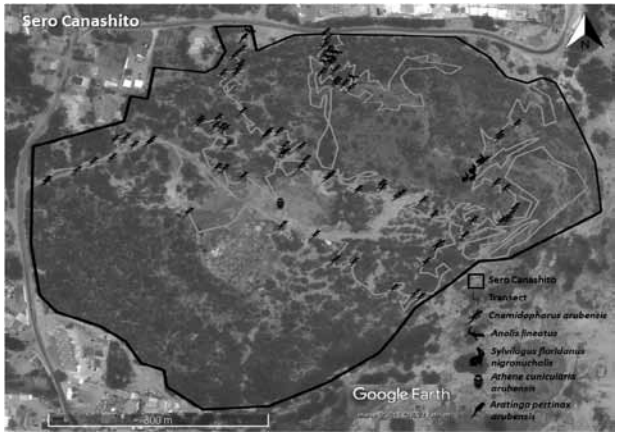

Figure 4

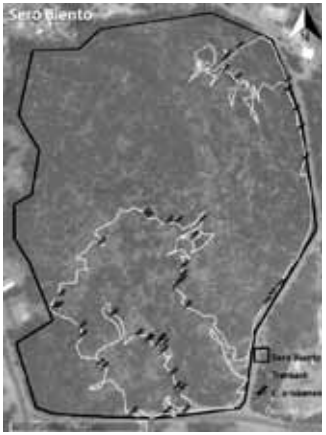

Figure 5

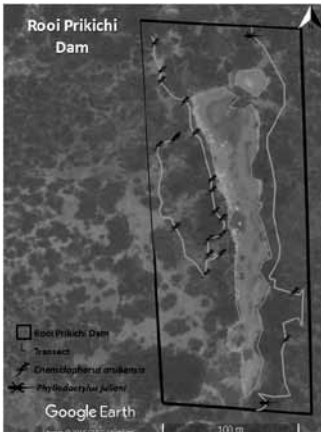

Figure 6

Figure 2- Map of research area 'California', the accomplished transects, and species location on transects.
Figure 3- Map of research area 'Hooiberg', the accomplished transects, and species locations on transects.
Figure 4- Map of research area 'Sero Canashito', the accomplished transects, and species locations on transects.
Figure 5- Map of research area 'Sero Biento', the accomplished transects, and species locations on transects.
Figure 6- Map of research area 'Rooi Prikichi Dam', the accomplished transects, and species locations on transects.

Table 3 additionally yields the result of the Shannon-Weaver Index and the Pielou Index. The calculated species richness shows that the RA with the most species is Sero Canashito with 5 species present, followed equally by Hooiberg with 3 species, thereafter California and Rooi Prikichi Dam with 2 species each, and lastly Sero Biento with 1 species. Results of the Shannon-Weaver Index for species diversity yielded that Sero Canashito has the highest species diversity, followed by Hooiberg, Rooi Prikichi Dam, California, and Sero Biento. The Pielou Index places Sero Canashito with the highest species evenness, and in second place Hooiberg and Rooi Prikichi Dam with an equal evenness of 0.39, with a subsequent order of California and Sero Biento.

Discussion and Conclusion

A number of observations and patterns were noted on the different species of endemic fauna during fieldwork. Firstly, discrepancies in ground truth data may be largely attributed to unseen and unidentified individuals. During fieldwork, individuals were heard but not seen in all RAs. Adding them to the count would result in unreliable data, as they may not have been correctly identified. Additionally, some species are easier to spot, in particular dimorphic species such as the Aruban whiptail lizard and the Striped anole, where males are a bright turquoise color in the former, and a light green in the latter. This may cause discrepancies in the observed male to female ratio.

The Aruban whiptail lizard was present in all habitats. This lizard is known to be widely abundant on the island. Their numbers have even grown further since the introduction of the *Boa constrictor* (Goessling et al., 2015). Their distribution throughout different habitats within the RAs showed a number of similar observations. In the area of California, as the transects moved inland, the more dominant the vegetation, although the flora present grows in patches surrounded by open area. Interestingly, the Aruban whiptail lizards abundance increased in a similar manner, particularly that of adults. On the limestone shore, none were present. Consequently, the abundance of the Aruban whiptail lizard appears correlated to the increase in vegetation in California. In Sero Canashito, barely any individuals were found in the thick vegetation on the northern side. On the other hand, in the excavated area, where there now grow a number of bushes surrounded by open ground, there was a high density. A commonality of both these areas of high abundance, was bushes surrounded by ground, open to direct sunlight. According to Schall's (1974) study on this species preferred habitat type, this form of habitat is one of the optimal candidates.

Hummelinck (1940), states that specimens of the striped anole have been collected from Hooiberg, but none were found during this research. This species of anole is present on Curacao in large numbers, and ongoing research reveals that they are found in urban and in natural environments. It can be hypothesized that because the findings on Aruba were prior to the arrival of the *Boa constrictor*, they may no longer be applicable. This is due to the life habits of the two species, which spend the majority of their time on trees. As the anoles sleep at night, the boas hunt in the trees. Further research is needed to determine if there is indeed a correlation between the arrival of the boa and the population density of the striped anole on Aruba.

Specimens of the Aruban leaf-toed gecko, on which little is known, were collected from Hooiberg and Sero Canashito in the past (Hummelinck, 1940). None were spotted in either areas during this research. Nonetheless, it cannot be concluded that they are not present, as they are difficult to find, spending the majority of their time underneath tree bark. It appears that unlike its nearest relative *P. martini* of Curacao, the Aruban leaf-toed gecko is not widespread nor abundant on the island (IUCN, 2016). Further research is necessary to gain a better understanding of their life habits and distribution. Danger to their population comes not only from human development, but

also as a consequence of potential competition from the newly invasive cosmopolitan house gecko, *Hemidactylus mabouia* (van Buurt, 2012). It was noted during fieldwork that on trees where the Aruban leaf-toed gecko were found, more gecko species were also present, in particular *Gonatodes vittatus vittatus*. However where *Thecadactylus rapicauda* was found, the second native large gecko (van Buurt, 2015), no Aruban leaf-toed geckos were found.

The habits of the Aruban island rattlesnake are well studied. It is known that they do not stray far from their territory, and although they live in solitary, they may be found in close proximity (Reinert et al., 2002). From the known distribution map of these snakes, it is not surprising that none were found in the majority of RAs. However, Rooi Prikichi Dam appears to fall within their known locations (Reinert et al., 2002). This may or may not be as a result of interpolation on the map between where specimens were found. Further investigations will reveal whether they utilize this habitat.

The Aruban cottontail rabbits on Sero Canashito were not live specimens, but skulls, as identified through literary analysis (Bekker, 1996). It was not possible to verify whether living specimens reside on the hill, because its substrate does not show paw prints. In contrast, prints were found on the base of Hooiberg, although no specimens were spotted. Additionally, prints were found in two rooien leading to the Rooi Prikichi Dam. As they were outside the RA boundaries, they were not included in the results.

For the majority of the studied species, extrapolation does not appear useful to gauge their true densities. For example, the brown-throated parakeet were spotted in Sero Canashito. However no nest was found, and they were spotted leaving the RA. Therefore although they may pass through the RA, their numbers differ constantly, so extrapolation proves unreliable. This may also be the cause for why they were not spotted on Hooiberg and California, where they had previously been sighted (Derix, Peterson, and Marquez, 2013).

For the Aruban burrowing owl the case is slightly different, as they nest on the ground and are known to stay in the same territory. These owls require substrate in which they can dig out burrows with their claws, limiting them to sandy areas which may not encompass the entire RA. In the past they were noted to appear communally on the north coast, in the vicinity of the California RA. This is no longer the case (Derix, Peterson, and Marquez, 2013), thus extrapolation proves unreliable. Although Derix, Peterson, and Marquez (2013) report that the Aruban burrowing owl was present in the Rooi Prikichi Dam area, none were found during this research.

Lizard populations on islands are dense (Benett and Gorman, 1979), and their territories small. Hence, the extrapolation does not have as large a margin of error as it does for the bird species, and therefore proves useful. For the only mammal, the Aruban cottontail rabbit, no data was found on known densities or life habits, with the exception their preference for nocturnal foraging. Accordingly, it is not possible to say whether extrapolation is useful.

Differences in species composition in the different RAs are not surprising, as they sufficiently encompass different habitats. California is a sandy, relatively barren, area. Hooiberg, with its steep slopes, is densely vegetated at the base and top. The dominant vegetation is *acacia* and *Cereus repandum*. Sero Canashito has a number of different sub-habitats. On the northern slopes, the vegetation is dense, with trees such as *Guaiacum officinale* and *Quadrella odoratissima*, and the understory with *Aloe vera* and *agave*. The top of the hill is a reef terrace with little vegetation. On the western side, there is a barren excavated area dominated by a sandy substrate and mounds of sand. On the south, an *acacia* forest dominates with an *agave* understory. Sero Biento is densely vegetated at the base with *acacia* and *Cereus repandum*, and the understory is dominated by *Aloe vera* and *agave*. The higher elevations are similarly yet sparsely vegetated. Rooi Prikichi Dam is dominated by a temporary water body, still present in the months after

the rain season. The ground is alternately grassy and rocky, and *acacia* and *Stenocereus griseus* form a sparse forest. These different habitats suit different species, but additional factors such as anthropogenic impact, food availability, as well as competition and/or predation from other species, may all have an effect on their presence.

When plotting the number of individuals of species to the function of RA size, the area was rescaled by resizing to the power of 0.25, which is an approximation of log-transformation and makes the distribution less skewed. Figure 2 shows a positive correlation between the number of species individuals with increasing size of each RA. This can be explained through the theory of island biogeography, which suggests that a smaller fragment or island has a lower potential equilibrium for the number of species. It also supposes that areas ten times as large hold twice as many individuals of these species. Neither of these are linear relationships, and therefore although the comparison between the equilibrium is not correct for this research, as only endemic species were accounted for, it does explain why the individual to area ratio appeared higher in the smaller RAs in the initial calculations.

The difference in ranking between the species richness and the species evenness can be explained by the increased result of the evenness as a consequence of the number of individuals being spread more evenly between the present species. However, habitat quality also affects the numbers of individuals present, therefore looking at the relative ranks of the number of individuals per area and evenness, a different pattern emerges. Species richness, diversity, and evenness, all have the same ranking, only slightly differing in that Rooi Prikichi Dam was alternately even with California in species richness, and with Hooiberg in species evenness.

From initial literary analysis, it was expected that 5 of the 7 species would be present in both Hooiberg and Rooi Prikichi Dam. This would have increased their results for species richness and diversity, but without knowledge of the species density, it is unclear whether the species evenness would have increased. Although California and Hooiberg maintained a midstream score on all counts, they are also the most anthropogenically impacted. Therefore, changing their status to conservation areas may not be as effective in the long term, if continuous visitation to these areas is permitted. Lastly, Sero Biento scored lowest in species richness, diversity, and evenness, due to the presence of only one species. However, further research should be conducted in this area on endemic flora, in particular *agave*, which were found in abundance, and therefore may increase the areas importance for conservation.

The Caribbean hotspot as described by Myers et al. (2000) identified Park Arikok as a contributing habitat for the preservation of endemic biodiversity. This research has revealed that a number of Aruba's endemic species are likely disappearing from their former range. Although Park Arikok is of significant size, it can only contain a limited population of Aruba's endemic species. Individually, the RAs analyzed in this paper may not appear significant in comparison to the park's size and species richness. However, together they encompass habitats suitable for all of Aruba's endemic fauna species. In conclusion, it is imperative to establish their status as legal conservation areas.

Bibliography

Aho, K. Pielou's measure of species evenness. https://artax.karlin.mff.cuni.cz/r-help/library/asbio/html/evenness.html.

Beals, M., Gross, L., Harrell, S. (2000). Diversity Indices: Shannon's H and E. http://www.tiem.utk.edu/~gross/bioed/bealsmodules/shannonDI.html.

Bekker, J. P. (1996). The mammals of Aruba. *Nijmegen: Vereniging voor Zoogdierkunde en Zoogdierbescherming*.

Bennett, A. F., & Gorman, G. C. (1979). Population density and energetics of lizards on a tropical island. *Oecologia*, *42*(3), 339-358.

BEST (2016). Biodiversity and Ecosystem Services in Territories of European Overseas (BEST 2.0).

DCNA (2014). Aruban Burrowing Owl- Detail Page. http://www.dcnanature.org/aruban-burrowing-owl-detail-page/.

DCNA (2014). Leeward Island endemic species.

DCNA (2017). Prikichi declared Aruba national bird. http://www.dcnanature.org/prikichi-aruba-national-bird/.

Derix, R., Peterson, G., Marquez, D. (2013). The National Bird Count in 2011 in Aruba. Central Bureau of Statistics (CBS) Aruba, Dept. Environmental Statistics.

Derix, R.W.M. (2016). *A review of Geology, Climate and Hydrology in Aruba.Central Bureau of Statistics Aruba.*

Directie Natuur en Milieu. *Ontwerp nota aangewezen beschermde gebieden.*

Dixon, J. R. (1962). The leaf-toed geckos, genus Phyllodactylus, of northeastern South America. *The Southwestern Naturalist*, 211-226.

Foundation Parke Nacional Arikok. *Cododo.*

Foundation Parke Nacional Arikok. *Conew*.

Foundation Parke Nacional Arikok. *De Cascabel.*

Foundation Parke Nacional Arikok. *Gestreepte Boomhagedis.*

Foundation Parke Nacional Arikok.. *Shoco.*

Gartner, G. E., Gamble, T., Jaffe, A. L., Harrison, A., & Losos, J. B. (2013). Left–right dewlap asymmetry and phylogeography of *Anolis lineatus* on Aruba and Curaçao. *Biological Journal of the Linnean Society*, *110*(2), 409-426.

Harari, Y. N. (2014). *Sapiens: A brief history of humankind*. Random House.

Hummelinck, P. W. (1940). Studies on the Fauna of Curaçao, Aruba, Bonaire and the Venezuelan Islands: No. 4. *Stat*, *185*, 185A.

IUCN Red List of Threatened Species. http://www.iucnredlist.org/search.

Myers, N., Mittermeier, R. A., Mittermeier, C. G., Da Fonseca, G. A., & Kent, J. (2000). Biodiversity hotspots for conservation priorities. *Nature*, *403*(6772), 853-858.

Reinert, H. K., Bushar, L. M., Rocco, G. L., Goode, M., & Odum, R. A. (2002). Distribution of the Aruba Island rattlesnake, *Crotalus unicolor*, on Aruba, Dutch West Indies. *Caribbean Journal of Science*, *38*(1/2), 126-128.

Ruimtelijk Ontwikkelingsplan Aruba Planbeschrijving (ROP). (2009). Vastgesteld bij Landsbesluit van 7 mei 2009, no. 7.

Schall, J. J. (1974). Population structure of the Aruban whiptail lizard, *Cnemidophorus arubensis*, in varied habitats. *Herpetologica*, 38-44.

Steffen, W., Richardson, K., Rockström, J., Cornell, S. E., Fetzer, I., Bennett, E. M., ... & Folke, C. (2015). Planetary boundaries: Guiding human development on a changing planet. *Science*, *347*(6223), 1259855.

Tilman, D., May, R. M., Lehman, C. L., & Nowak, M. A. (1994). Habitat destruction and the extinction debt.

Trent, T. T., & Rongstad, O. J. (1974). Home range and survival of cottontail rabbits in southwestern Wisconsin. *The Journal of Wildlife Management*, 459-472.

Van Buurt, G. (2015). Conservation of amphibians and reptiles on Aruba, Curacao, and Bonaire. Herpetology,

Van Buurt, G., O. Debrot, A. (2012). Exotic and invasive terrestrial and freshwater animal species in the Dutch Caribbean.

van Proosdij, A. S. J. (2001). *Arnoldo's pocket flora: what grows and blooms in the wild on Aruba, Bonaire and Curaçao.*