Environmental Impact Report for Off Road Driving (ORD) in Parke Nacional Arikok

PARKE NACIONAL
ARUBA

Environmental Impact Report for Off Road Driving (ORD) in Parke Nacional Arikok © Fundacion Parke Nacional Aruba (FPNA)

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Cover photos (FPNA): Collage of several environmental impact assessment topics.

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1. Introduction

Fundacion Parke Nacional Aruba (FPNA) is foremost a nature conservation organization, placing Nature First to increase and maintain biodiversity and prevent impairment of park resources and values. FPNA thereby ensures that conservation is predominant when there is a conflict between the protection of biodiversity and resources, and their use.
The primary aim of FPNA is the conservation of Aruba's unique and diverse natural habitats and species, to enhance biodiversity and resilience through evidence-based, adaptive management. This includes the protection, restoration, rehabilitation, monitoring and adaptive, evidence-based conservation management of an area, resource or species to prevent exploitation, destruction, decline or neglect; ultimately aimed at securing a measurable improvement in the overall health, resilience and biodiversity of Aruba's ecosystems.

Aruba has overstretched its resources beyond sustainable levels (ATA 2018). One of numerous factors putting pressure on Aruba's natural resources is off-road driving (ORD). There has been a significant increase in ORD in Aruba in recent years, with negative social and ecological impacts on nature and no proper laws or enforcement to regulate ORD (Nieuw & Nieuw 2020). With visitation to Parke Nacional Arikok - one of the management areas of the FPNA - increasing annually by an average of 15% over the last three years, FPNA has directed her energies to placing signage at key points in the park and increasing enforcement of the park rules and regulations. As a consequence of a preliminary impact assessment by FPNA of the Shete-Conchi area, the Shete entrance to Parke Nacional Arikok was closed in 2019, thereby reducing the access area being impacted for reaching Conchi (Natural Pool) - the most popular destination in Parke Nacional Arikok - while still ensuring accessibility via the main entrance at San Fuego.
Certain areas in Parke Nacional Arikok can have a daily average of 715 vehicles going towards and coming back from frequently visited areas, with negative effects on the natural areas within the reserve (Stevens 2019). Several additional surveys have since then indicated the severity and continuity of the impact of ORD.

In 2019, also popular protest was on the rise as to the effects of ORD. Several interest groups, including of the neighborhood to Parke Nacional Arikok, requested meetings with FPNA to voice their concerns and impairment from both social and environmental impacts of ORD. As a consequence of these concerns and also on the basis of preliminary environmental impact assessments carried out, FPNA has developed and implemented a policy to phase out the high-impact ORD within Parke Nacional Arikok, which has been impairing the natural values of this managed protected area. This three-phased policy was presented on 7 May 2020 (with phase one kicking-off on 1 June 2020) and will help safeguard the protected nature reserve from high-impact ORD - which is of great concern to nature enthusiasts, NGOs protecting Aruba's nature, citizens and those who enjoy outdoor recreation. FPNA hereby emphasizes that Parke Nacional Arikok is a nature reserve by law, and not primarily a recreation area or theme park.

<u>Conchi - the most visited site in Parke Nacional Arikok</u>

Conchi - or Natural Pool - is one of the most popular attractions on Aruba. It is located in Parke Nacional Arikok and is the most visited site in the park. Vehicles heading to Conchi need to pass through the main entrance to Parke Nacional Arikok at San Fuego, since the closing of the Shete entrance to Conchi on 1 April 2019. The conservation motivations for closing Shete can be found in Annex 1, which illustrates the social and environmental impact of high traffic ORD on dirt roads.

In 2016, Oosterhuis created a projection map for risks to vegetation from effects of ORD for the northern parts of Parke Nacional Arikok, between Sero Arikok (Arikok Hill) and Daimari (fig. 1). The San Fuego to Sero Arikok road has not been included in the Oosterhuis map, but will be the focus of the FPNA ORD research.

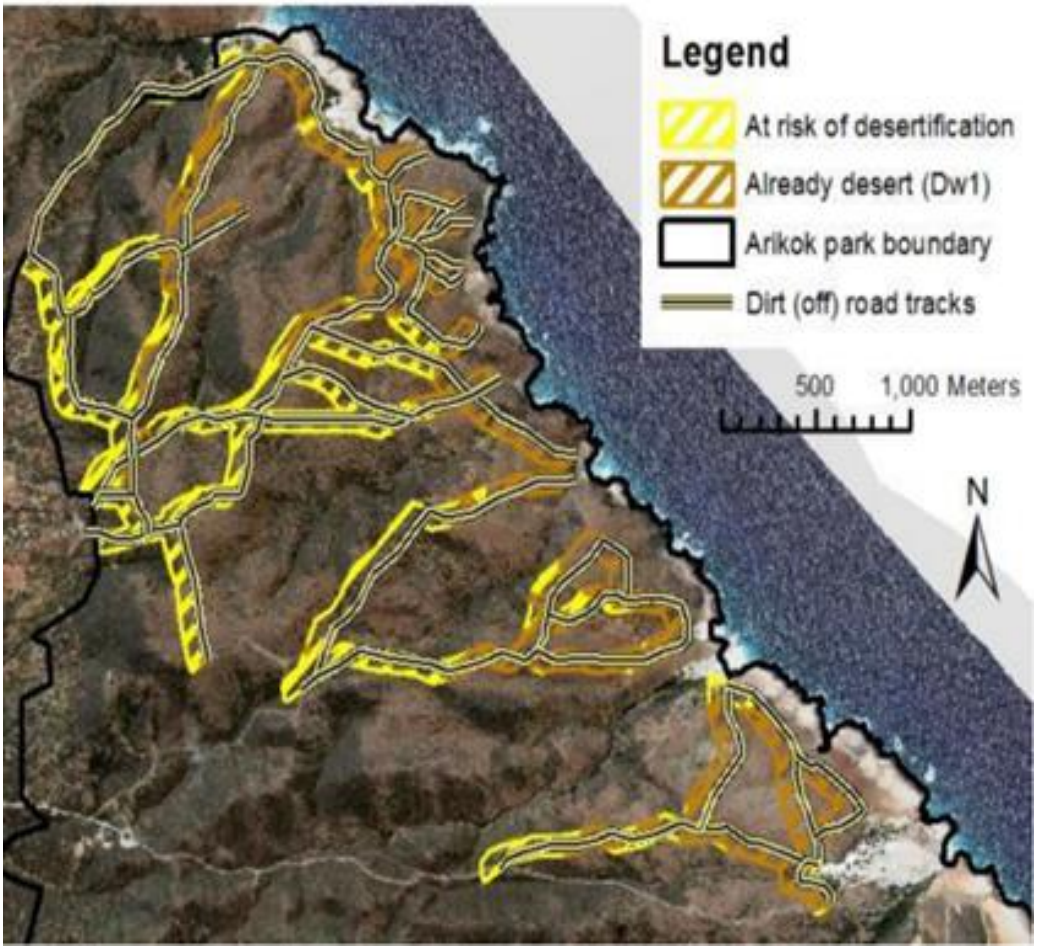

Figure 1: A theoretical risk map of vegetation due to the effects of off-road driving, taken from (Oosterhuis, 2016). Road San Fuego to Sero Arikok not included.

In 2017, Vogel showed how ORD creates dust clouds on Aruba. In 2019, Stevens showed that vegetation, soil stability, water infiltration, and nutrient cycling were negatively impacted in areas with ORD (fig. 2 and fig. 3). Areas with ORD had significantly more desert-like, bare ground with no vegetation cover.

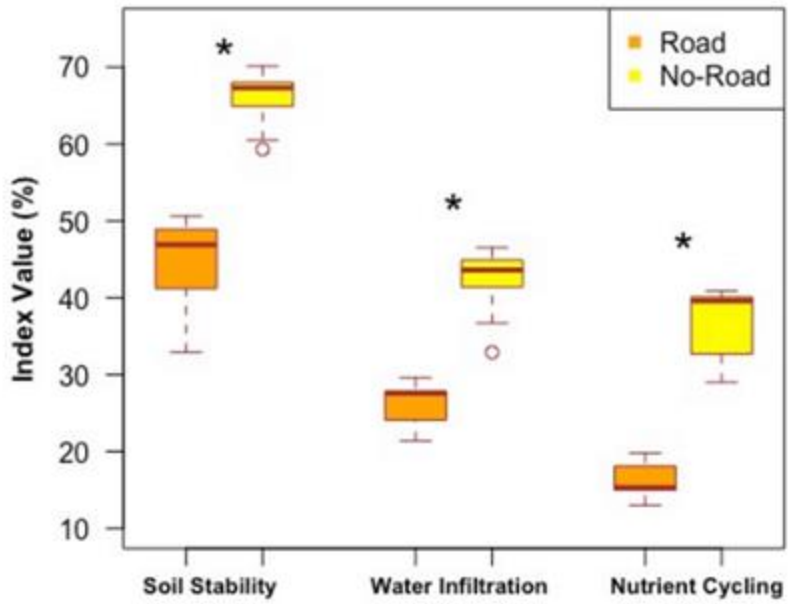

Figure 2: Comparison between road and no-road areas for soil stability, water infiltration, and nutrient cycling.

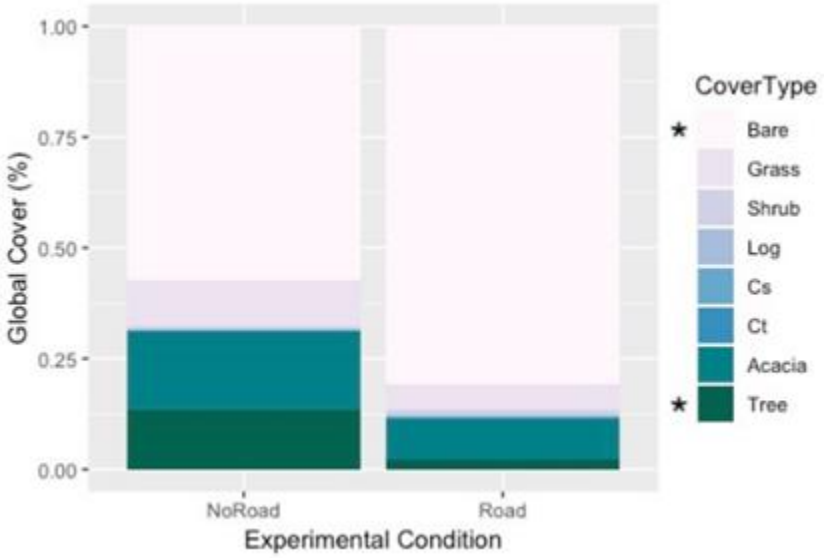

Figure 3: Comparison between road and no-road areas for bare ground and vegetation cover.

Parke Nacional Arikok underwent a forced closure for motorized vehicles from 23 March until 1 June 2020, due to the pandemic Covid-19 measures. This presented an opportunity to analyze the pre Covid-19 conditions under high-impact use for ORD and compare these after a two-month Covid-19 closure of the national park, specifically for (the route to) Conchi - the most visited site in the park.

Evidence-based and adaptive management

FPNA applies evidence-based, adaptive management and conservation practices to address issues, deliver conservation objectives and critically evaluate all conservation endeavors. Under 'evidence based'[1] conservation we consider the application of evidence in conservation management actions and policymaking.

FPNA also applies adaptive management, as is increasingly the modus operandi for conservation management organizations all over the world. Adaptive management is a process that promotes flexible decision making, that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances (scientific) understanding and helps adjust policies or operations as part of an iterative learning process. Adaptive management also recognizes the importance of natural variability in contributing to ecological resilience and productivity. It is not a 'trial and error' process, but rather emphasizes learning while doing. It gives special emphasis to uncertainty about management impacts, iterative learning to reduce uncertainty, and improved management as a result of learning.

Furthermore, whenever and wherever necessary, FPNA applies the Precautionary Principle as a strategy to cope with possible risks where scientific understanding is yet incomplete – as in this particular instance, with mounting evidence on the impairment of our protected nature through high-impact human activity from ORD.

The impacts of off-road driving (ORD)

Scientific and evidence-based research shows that unsustainable ORD results in negative social, ecological and environmental impacts (Assaeed *et al.* 2019, Farr *et al.* 2017, Vogel 2017, Goossens & Buck 2009, and Goossens & Buck 2014, Khan & Strand 2018, Nieuw & Nieuw 2020).

The social and ecological/environmental impacts of ORD relevant for Parke Nacional Arikok are:

a. Social impacts on people:
- Traffic dangers
- Exhaust fumes (impacts respiratory system)
- Dust pollution (impacts respiratory system)
- Ground vibrations (impacts stress level)
- Sound pollution (impacts hearing and increases stress level)
- Reduced experience for people practicing outdoor recreation and physical activities

[1] 'Evidence-based' is defined as systematically assessing scientific information from published, peer-reviewed publications and texts, practitioners' experiences, independent expert assessment, and local and indigenous knowledge, visitor reviews/comments, field observations, incident reports, press reports – amongst other information sources - on a specific conservation topic. This includes assessing the current effectiveness of different management interventions, threats and emerging problems, and economic factors.

b. Ecological impacts on flora and fauna biodiversity of natural areas, both terrestrial and marine, and environmental impacts:

- Ecological Impacts come from:
    - Loss of nature space and fragmentation
    - Trampling in wildlife areas
    - Unauthorised creation of new roads
    - Dust pollution (which can travel 1 km or more depending on wind)
    - Sound pollution (stressed fauna, site abandonment)
    - Soil pollution from oil leakages
    - Air pollution from exhaust fumes
    - Soil erosion and degradation
    - Impact on coastal waters, for example:
        - Sedimentation (reduces water quality, negatively impacts flora and fauna)
        - Eutrophication (negatively impacts water quality, affects flora and fauna)

- Impact on Flora health and survival:
    - Dust covering entire plant, including leaves (impacting respiration and energy production)
    - Soil erosion
    - Reduced soil water retention

- Impact on Fauna feeding, breeding, and resting sites, for example:
    - Birds, including ground-dwelling and coastal birds
    - Reptiles, including lizards, snakes and sea turtles
    - Mammals, such as cotton-tail rabbits, bats and vesper mice
    - Insects, such as bees, butterflies and dragonflies
    - Fish and Crustaceans, especially in mangroves and coastal areas

- Impact on different Ecosystem services obtained from numerous flora species, for example:
    - Shift from trees and shrubs (xeric) ecosystem to grass, herbaceous plants or desert ecosystems
    - Loss of food sources for fauna
    - Loss of shelter for fauna
    - Loss of nests for fauna
    - Impacted geological and ecological features:
        - Limestone terraces
        - Lava Rock formations
        - Diabase hills
        - Beaches
        - Dunes
        - Flatlands
        - Wetlands

Although the impacts of ORD are numerous, this report presents preliminary surveys done during 2019 and 2020. The first part of the road to Conchi was surveyed as it still has a relatively high vegetation density and allows for measurements of the impact on flora. Also a preliminary comparison of illegal road creation and road widening between 2002 and 2020 along part of the road to Conchi was made, sedimentation into the sea was documented, siltation in Rooi systems was documented, an inventory of protected species affected by ORD in the areas adjacent to the road, and an inventory of traffic accidents in Parke Nacional Arikok. The coming chapters will present the methods applied and the results, followed by a discussion of these results and the conclusion.

2. Methods

Surveys were done by FPNA on the dirt road from San Fuego to Conchi during the Dry Season (April 2019), during the Rainy Season (September 2019) and during the Covid-19 closure of Parke Nacional Arikok (April-May 2020) for motorized vehicles to assess environmental impacts that ORD is having on this particular area.

Survey Areas

The surveyed road section runs from the San Fuego entrance to Sero Arikok - a distance of 1.5 kilometers (fig. 4); and the Sero Arikok to Conchi road - a distance of 3 kilometers (fig. 5).

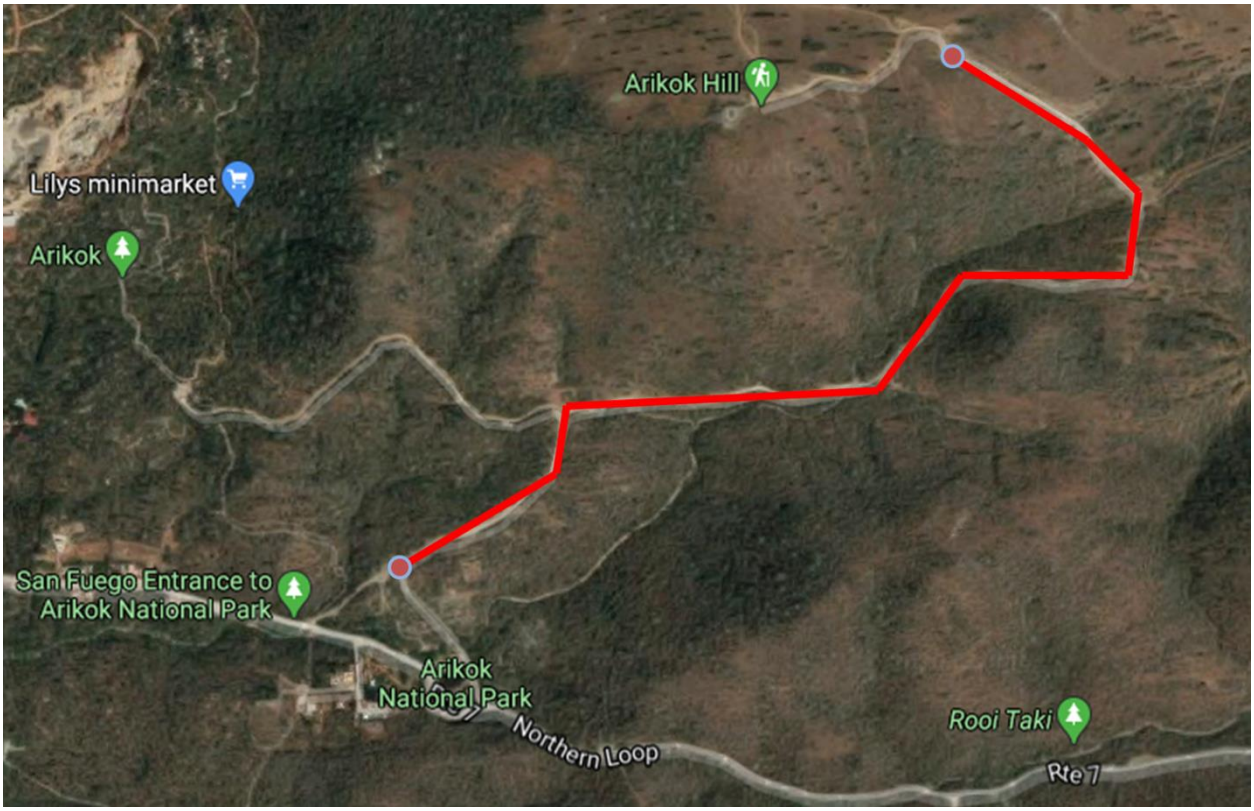

Figure 4: The San Fuego To Sero Arikok road surveyed for ORD.

Figure 5: The Sero Arikok to Conchi road surveyed for ORD.

Dry season 2019

The San Fuego to Sero Arikok road was monitored on 1-2 April 2019 to assess the effect that ORD has on the vegetation.

Dust Impact

1. Vehicle dust clouds: Vehicles were followed and filmed. Screenshots were taken to show dust clouds created by fast driving vehicles.
2. Dust cover vegetation: Dust on vegetation was photographed.
3. Up- versus downwind dust cover: Comparison photos were made of dust on vegetation for plants up and down wind from the road to illustrate the impact ORD has on the vegetation. All picture comparisons were taken across the road from each other.
4. 24-hour dust cover experiment: White cloths were placed at different areas along the down-wind side of the dirt road to illustrate how much dust is collected during a 24-hour period. A clean white control cloth (cloth "C") is photographed next to the cloths used during the experiment to illustrate the amount of dust covering the experimental cloths. Cloth # 1 was placed next to a concrete road, cloth #2 to #5 were placed next to a dirt road, and cloth #6 was placed next to an asphalt road. The three different roadsides can all be found on the same stretch of road from San Fuego to Sero Arikok.

Rainy season 2019

There was heavy rainfall the night of 19 September 2019. The San Fuego to Sero Arikok road was surveyed on 20 September 2019 to assess the effect of rain on the dust impacted flora.

Dust Impact

1. Dust cover vegetation: Dust on vegetation was photographed.
2. Up- versus downwind dust cover: Comparison photos were made of dust on vegetation, for plants up and down wind from the road to illustrate the impact rain has on the vegetation which was surveyed for dust impact in April. All picture comparisons were taken across the road from each other.

Leaf Abundance

1. Up- versus downwind leaf abundance: Comparison photos were made of leaf abundance on vegetation, for plants up and down wind from the road, to illustrate the impact rain has on the vegetation which was surveyed for dust impact in April. All picture comparisons were taken across the road from each other.

Sedimentation into the Parke Marino Aruba, MPA Arikok

On September 23rd 2019 there was heavy rainfall and the impact of sedimentation into the sea due to ORD soil erosion was recorded and photographed.

Dry season 2020, during Covid-19 closure

Dust Impact

1. Dust cover on vegetation was photographed during the 2 month Covid related closure to motorized vehicles of Parke Nacional Arikok.

Siltation in Rooi systems

1. Siltation in the San Fuego area Rooi systems was assessed by comparing the 2008 and the 2020 picture of a road pipe water catchment system.
2. Comparisons were also made between rooi sections directly connected to dirt roads used for ORD and rooi sections not directly connected to dirt roads used for ORD.

Unauthorised Road Creation and Road Widening 2002-2020

1. Unauthorised Road Creation was assessed by comparing Google Earth images in Parke Nacional Arikok between 2002 and 2020.
2. Road Widening in Parke Nacional Arikok 2020 was photographed.

Presence Protected Species 2020[2]

1. Cascabel
2. Shoco
3. Conew
4. Prikichi
5. Yuwana

ORD oil spill in Parke Nacional Arikok 2020

1. Oil spill from UTV was recorded in Parke Nacional Arikok

ORD accidents in Parke Nacional Arikok 2018-2020

1. A list of road accidents was compiled from FPNAs incidents reports and from news coverage archives.

[2] This list is yet incomplete as only flora and fauna in a limited time and area along a section of the San Fuego-Conchi road was surveyed.

3. Results

Dry Season 2019

Dust Impact

1. ORD dust clouds

Dust clouds can be seen created by ORD (fig. 6). Figure 3 consists of screenshots from numerous films available at FPNA.

Figure 6: Dust clouds created by ORD.

2. Dust cover on vegetation

Dust can be seen covering the vegetation as a result of the dust clouds created by ORD (fig. 7). Notice how the vegetation has the same colour as the dirt road.

Figure 7: ORD dust covering vegetation

3. Upwind versus downwind dust cover

A difference in dust cover from ORD can be seen between vegetation growing upwind (not impacted by ORD dust) versus downwind (impacted by ORD dust) from dirt roads (fig. 8-9). The left column shows the not impacted vegetation and the right column the impacted vegetation. All side-by-side picture comparisons were taken across the road from each other at the same time and day.

Figure 8: Comparison of vegetation on opposite sides of the road. Dust impact between upwind (left picture, low impact) versus downwind (right picture, high impact) can be seen.

Figure 9: Comparison of vegetation on opposite sides of the road. Dust impact between upwind (left picture, low impact) versus downwind (right picture, high impact) can be seen.

4. 24-hour dust cover versus no-dust experiment

Some dust was collected on cloth #1 and no dust was collected on cloth #6 when placed for 24 hours next to the concrete and asphalt road, respectively (fig. 10). Note that vehicles sometimes drive on the dirt next to the concrete road strips leading up the Sero Arikok, while that is not possible at the beginning of the route to Conchi, where the road is asphalted. A lot of dust was collected on clothes #2, #3, #4, and #5 which were next to the dirt road for 24 hours. The cloths placed in the field were compared to a clean control cloth marked as "C" in figure 10.

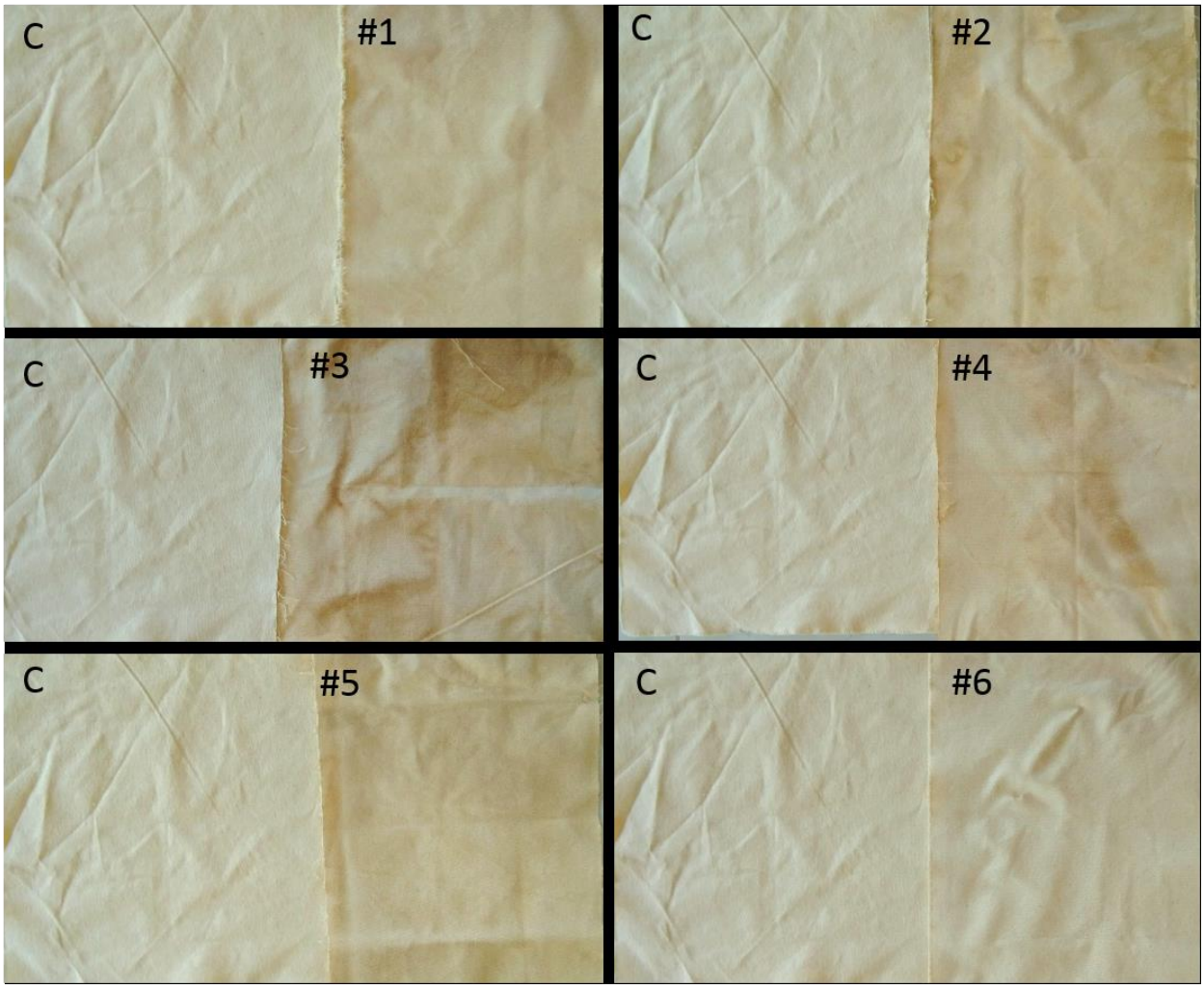

Figure 10: Dust collected during 24 hours on cloths placed next to concrete road (#1), dirt road (#2-#5), and asphalt road (#6)

Rainy Season 2019

Dust Impact on vegetation

1. Dust cover vegetation

Dust can be seen covering the vegetation after the rainfall (fig.11). The dust has formed a thick, muddy, caked layer on the plants (fig. 12).

Figure 11: Dust from vehicle dust clouds covering vegetation.

Figure 12: Muddy cake layer from dust mixed with rain water on cacti and tuna.

2. Upwind versus downwind dust cover

A difference in dust cover from ORD can be seen between vegetation growing upwind (not impacted by ORD dust) versus downwind (impacted by ORD dust) from dirt roads (fig. 13). The left column shows the not impacted vegetation and the right column the impacted vegetation. All side-by-side picture comparisons were taken across the road from each other at the same time and day. Figure 14 shows a panoramic view of dust impact, which can be seen between the ORD impacted side on the left and the not ORD impacted side on the right.

Figure 13: Comparison of vegetation on opposite sides of the road. Dust impact between upwind (left picture, low impact) versus downwind (right picture, high impact) can be seen.

Figure 14: Comparison of vegetation on opposite sides of the road. Difference in dust cover can be seen between the upwind (right side of the road) and downwind (left side of the road) vegetation.

3. Leaf Abundance

A difference in leaf abundance can be seen between vegetation growing upwind (not impacted by ORD dust) versus downwind (impacted by ORD dust) from dirt roads (fig. 15). The left column shows the not impacted vegetation and the right column the impacted vegetation. All side-by-side picture comparisons were taken across the road from each other at the same time and day.

Figure 15: Comparison of leaf abundance on vegetation on opposite sides of the road. Difference in leaf abundance between upwind (left picture, low impact) versus downwind (right picture, high impact) can be seen.

4. Terrigenous sedimentation in the adjacent Marine Protected Area (MPA) Arikok

In September 2019 the sea changed to a brown color indicating large amounts of sediment entering the sea from connected land-based sources as a result of ORD induced erosion (fig. 16). The land area affecting the MPA Arikok - which is part of the Parke Marino Aruba - is heavily used for ORD, especially for reaching Conchi. On the whole, activities which are carried out by man - such as agriculture and mining but also ORD, often change the processes of erosion and sedimentation as well as modifying the flow of roois and the amount of sediment carried to water systems and ultimately, the sea.

Figure 16: MPA Arikok areas affected by sedimentation due to sediment runoff from land based sources impacted by ORD.

Dry season 2020, during Covid-19 closure (April 2nd 2020)

Dust Impact on vegetation

1. Dust Cover Vegetation
   New growth on the flora during the Covid-19 closure of the park looks green and has no dust cover. The older growth looks brownish grey and is covered in Pre Covid-19 ORD related dust (fig. 17).

Figure 17: New growth during Covid-19 closure has no dust cover while older growth on the same vegetation is covered in pre Covid-19 dust.

2. Sedimentation in Rooi systems

The rooi systems in the San Fuego area connected to ORD impacted areas are being buried in silt from erosion caused by ORD, as can be seen in the 2008 and 2020 comparison of an under the road pipe system being filled with silt (fig. 18). Comparisons with the San Fuego rooi systems in areas further away from dirt roads that are frequented by ORD, show considerably less impact, i.e. less silt than rooi systems near dirt roads heavily frequented by ORD (fig. 19).

Figure 18: Comparison of level of sedimentation in structures of road pipe system between 2008 (left) and 2020 (right).

Figure 19: Comparison between rooi sections not directly connected to dirt roads used for ORD (left) and rooi sections directly connected to dirt roads used for ORD (right).

Unauthorised Road Creation and Road Widening

1. The road to Conchi has been in use for decades before the area became a national park in 2000. The satellite image shows that in the year 2020 more roads have been (illegally) created compared to the same sample area in 2002 (fig. 20). Vegetation can be seen expanding their range over the years except for along the road areas, illustrating the impact of ORD on vegetation health and connectivity. This is just one of many areas suffering from illegal road creation. GPS coordinates location: 12.518226, -69.938157.

Figure 20: Comparison of road surface areas in sample location between the year 2002 and 2020 (Google Earth).

2. The road has been widened in sample location (fig. 21 & 22). Here are just two examples of the many roads being illegally widened in Parke Nacional Arikok.
   GPS coordinates location: 12.507369, -69.942635
   12.509204, -69.943062

Figure 21: Authorised road width (green arrow) versus unauthorised road width created (illegally) by ORD (red arrow).

Figure 22: Authorised road width (green arrow) versus unauthorised road width (illegally) created by ORD (red arrow).

Presence of Protected Species

The Aruba Island Rattlesnake (Cascabel), Aruban burrowing owl (Shoco), Aruban cottontail (Conew), Aruban Brown-throated parakeet (Prikichi), and Green iguana (Yuwana) are endemic species - protected by law in accordance with Article 4 (first and second clause) and Article 26 (first clause) of the Nature Protection Ordinance (AB 1995 no. 2) - and have been recorded in the ORD vehicle areas in 2020. Many of the flora species - like columnar cactus *Stenocereus griseus* (Cadushi), *Opuntia caracassana* (Tuna) and *Quadrella indica* (Huliba macho) - that have already been shown to be impacted, fall under this same legal protection as well.

Cascabel

The endemic Cascabel is one of the most endangered species of rattlesnake in the world.

Cascabel are one of several species of road kill documented in ORD areas (fig. 23). Three cascabel road kills were recorded in ORD areas in January - March 2020 prior to the Covid-19 related closure of the area to motorized vehicles. During the Covid closure no road kills were recorded.

Fig. 23 Cascabel road kills on ORD trials (January to March 2020), predating Covid closure of Parke Nacional Arikok.

Shoco

A pair of endemic Shoco were observed using road pipes as a burrow on the route from San Fuego to Conchi (fig. 24). This nest is most likely several years old and predates the heavy traffic in the area. Other Shocos have also been spotted in the vicinity. ORD will further impact their habitat and their survival.

Figure 24: Pictures taken at an active Shoco burrow on the San Fuego section of the road to Conchi. Pictures: One of the two Shoco which inhabit the Shoco burrow; Side view of the Shoco burrow; Shoco feather at the burrow; Shoco leftover food at the burrow (lizard bones).

Conew

During the Covid-19 closure of the park to motorized vehicles, Conew were spotted foraging near the Visitor's Center at San Fuego during daylight hours. This is the first time in four years that this has been reported.

Prikichi & Termite Nest

The San Fuego area of Parke Nacional Arikok has had the endemic Brown-throated parakeets (Prikichi) in the past and these were seen again in trees and checking out termite nests as potential nesting sites (fig. 25), during the Covid-19 related closure to motorized vehicles, in areas adjacent to the road to Conchi. ORD will further impact their habitat and their survival.

Figure 25: Prikichi on top of termite nest at San Fuego area of Parke Nacional Arikok (Picture taken after forced Covid-19 closure of Parke Nacional Arikok).

Yuwana

A Green iguana (Yuwana) roadkill (fig.26) prior to the Covid-19 closure of the park for motorized vehicles. Also roadkill birds Tropical mockingbird and Ground dove (Chuchubi, Totolika) and Aruban whiptail lizards (Cododo) were recorded pre-Covid measures.

Figure 26: A green iguana roadkill observed directly after the passing of a group of UTVs.

ORD engine oil spill in Parke Nacional 2020

1. Oil spill from ORD was recorded prior to the Covid-19 closure of the park for motorized vehicles. A large amount of oil can be seen on the ground which then seeps into the ground (fig. 27).

Figure 27: Oil spill from ORD in Parke Nacional Arikok.

ORD accidents in Parke Nacional Arikok

Numerous ATV/UTV accidents have occured from 2018 to 2020 within Parke Nacional Arikok, of which a few are shown in figure 28 below. See the Reference List for a press overview of accidents within Parke Nacional Arikok between 2018 and the pre-Covid months of 2020.

Figure 28: Diverse ATV/UTV accidents requiring ranger, police, ambulance and/or fire department assistance.

4. Discussion

From the different surveys conducted in 2019 and 2020, we can see that ORD has numerous ways in which it can negatively impact the surrounding environment, in both social and ecological aspects. FPNA has and will continue adapting to conservation needs by creating management policies in order to mitigate the negative environmental effects from ORD.

Dust Impact on vegetation

The dust clouds created by ORD are damaging to native vegetation and have a negative impact on the ecosystem as seen in the dust impact analyses and other studies (Farmer 1993, Matsuki 2016). Rainfall creates muddy layers on dust covered vegetation and there is less leaf abundance on dust covered vegetation, indicative of reduced health. The previous findings indicate that the flora in off-road dust impacted areas is in a stage of degradation. Dust impacts can be seen over 200 meters away from the road. Observations show ORD creating dust clouds which then cover the surrounding natural features of Parke Nacional Arikok and may impact a significant area. The upwind versus downwind dust cover experiment showed the impact dust has on the natural environment by comparing the impacted flora to flora less impacted by dust. In the white cloth experiment, significant differences were seen between cloths in high ORD impacted roads and low ORD impacted roads. Continued ORD on the road to Conchi can ultimately lead to desertification of the San Fuego to Conchi area (Oosterhuis 2016, Stevens 2019).

Sedimentation in Rooi systems

ORD erodes soil layers (Webb 1978). Soil erosion enters Rooi systems, covering the natural mixture of gravel and rocky patches in uniform silt. Soil erosion negatively impacts the natural values of an area through, e.g. ground destabilization, reduced nutrient intake values, and changes in watershed properties (GWA 2017).

Terrigenous sedimentation in the adjacent MPA Arikok

ORD erodes soil layers (Webb 1978). Soil erosion enters Rooi systems and ends up in the sea bordering Parke Nacional Arikok as sedimentation. Sedimentation negatively impacts marine environments, e.g. loss of corals and seagrass beds (UNEP 2018), as it disturbs light penetration and causes an unnatural influx of nutrients and toxins.

Unauthorised Road Creation and Road Widening

The creation of illegal roads and the widening of roads increases the area size for negative ORD and road impacts on the natural environment. Ecological impacts from roads are, e.g. roadkill, habitat fragmentation, avoidance of road areas, interruption of horizontal ecological flows, and alteration of landscape spatial pattern (Coffin 2007, Forman & Alexander 1998, Hill 2019). Roadkill is especially bad for endangered species such as the protected Aruba Island Rattlesnake.

Covid-19 park closure impact on Flora and Fauna of Parke Nacional Arikok

Vegetation covered in ORD dust from previous years was still covered in old ORD dust after 2 months of no ORD activities in Parke Nacional Aruba. New leaf growth on dust covered vegetation had not collected high levels of dust after the Covid-19 closure and looked green instead of brownish grey, showing that vegetation became healthier in the absence of ORD (Farmer 1993). Changes in fauna behaviour patterns

during Covid closure to motorized vehicles were also observed. Numerous animals were more visible during the Covid related closure of Parke Nacional Arikok for motorized vehicles, also at locations not normally observed and at times not previously observed - including birds (shoco, prikichi, chuchubi, trupial, doves) and reptiles (snakes, lizards). Another significant difference during the Covid closure of Parke Nacional Arikok was that a plethora of birdsong could be heard for not being 'drowned' by ORD noise. These interesting observations prompt for further research and monitoring.

Presence Protected Fauna & Protected Fauna Roadkill

Article 4 (first and second clause) and Article 26 (first clause) of the Nature Protection Ordinance (AB 1995 no. 2) by law protects endangered, endemic, and/or species of high ecological value for Aruba from harm and disturbances. FPNA is foremost a nature conservation organization, placing Nature First to increase and maintain biodiversity and prevent impairment of park resources and values. FPNA thereby ensures that conservation is predominant when there is a conflict between the protection of biodiversity and resources, and their use. Several protected species have been observed in the ORD impacted areas of San Fuego during the Covid-19 closure of Parke Nacional Arikok, e.g. Cascabel, Shoco, Prikichi, and Conew. In 2020, before the Covid-19 closure, roadkill of protected Cascabel and Yuwana were documented in the San Fuego area of Parke Nacional Arikok impacted by ORD. Mitigating the death of endemic/endangered species from ORD activities is a high priority for FPNA.

ORD engine oil spill in Parke Nacional 2020

Engine oil pollution has mutagenic and carcinogenic properties and changes the nature of that environment, resulting in reduced ecosystem functionality. Oil pollution affects soil quality and inhibits plant growth through, e.g. changes in soil nutrient composition and reduced seedling viability (Kayode 2009, Vazquez-Duhalt 1989). ORD engine oil spill has been recorded on ORD roads in Parke Nacional Arikok. FPNA will continue to monitor this contaminant.

ORD accidents in Parke Nacional Arikok

One of the most severe social impacts of ORD is traffic accidents with human injuries and hospitalization. Accidents can occur from bad vehicle maintenance, e.g vehicles catching fire or losing wheels. Accidents also occur due to unsafe driving behaviours, e.g. speeding or driving under the influence. See the reference list for news articles regarding ORD accidents in Parke Nacional Arikok.

Future research will focus on the following topics:

- Further analyse the above discussed impacts of ORD in Parke Nacional Arikok;
- Further monitor impacts as presented above;
- ORD noise pollution in Parke Nacional Arikok (Dutta 2017,Fahrenkamp-Uppenbrink 2015, Francis *et al.* 2009);
- ORD speeds in Parke Nacional Arikok (Goossens & Buck 2014).

In continuing research and evidence gathering for environmental impact assessment purposes, relevant questions will also need to be addressed for future policy development:

- How should ORD areas be managed to reduce impact?
- What measures are there to minimize environmental impact?

- Which other types of environmental monitoring should be done?
- Which visitor amounts and frequency are environmentally sustainable per location?
- What noise and speed limits should apply, and which tire profile standards?
- Which motorised vehicles inherently have less environmental impacts? Which alternatives are there?
- Which enforcement methods can be used?
- Which regulations for environmental protection should apply? And which regulations are still missing?
- Should drivers be certified for (knowledge of) nature conservation and environmental sustainability?

5. Conclusion

Fundacion Parke Nacional Aruba (FPNA) executes her responsibilities as a nature conservation organization. In doing so, high-impact activities in FPNA management areas - including Parke Nacional Arikok - are monitored and regulated. Where necessary - and in accordance with national legislation and FPNA's articles of association - management measures and actions are taken to safeguard the nature under the organization's protection and care. Monitoring and surveying high impact activities is a necessary management policy. Hence in 2019 and 2020, FPNA surveyed the impact of ORD in Parke Nacional Arikok. In 2019 the entrance of Shete was closed to reduce the impacted area, with Conchi remaining accessible via the main entrance at San Fuego. Furthermore, surveys carried out in 2019 and 2020 illustrate the continuing social and ecological environmental damage being caused by ORD.

The impacts recorded from 2018 to 2020 were:

- Dust Impact on vegetation
- Sedimentation in rooi systems
- Terrigenous sedimentation in the adjacent Marine Protected Area (MPA Arikok)
- Unauthorised Road Creation and Road Widening
- Covid-19 park closure's positive impact on Flora and Fauna of Parke Nacional Arikok
- Presence Protected Fauna & Protected Fauna Roadkill
- ORD engine oil spill in Parke Nacional
- ORD accidents in Parke Nacional Arikok

Based on these preliminary findings, further research is being carried out for other environmental impacts, and adhering to the precautionary principle, FPNA has developed a new policy for ORD in Parke Nacional Arikok in order to mitigate the high impact of ORD. This new policy is effective as of 1 June 2020 and can be found on the FPNA website - www.arubanationalpark.org - under the title 'Policy Document. Managing Nature Conservation and High Impact Motorized Traffic' (FPNA, May 2020).

6. Reference list

Aruba Tourism Authority (ATA) (2018). A study on the Tourism Carrying Capacity for the Island of Aruba.

Assaeed, A. M., Al-Rowaily, S. L., El-Bana, M. I., Abood, A. A., Dar, B. A., & Hegazy, A. K. (2019). Impact of off-road vehicles on soil and vegetation in a desert rangeland in Saudi Arabia. Saudi Journal of Biological Sciences, 26(6), 1187-1193. doi:10.1016/j.sjbs.2018.05.001

Coffin, A. W. (2007). From roadkill to road ecology: A review of the ecological effects of roads. Journal of Transport Geography, 15(5), 396-406. doi:10.1016/j.jtrangeo.2006.11.006

Vazquez-Duhalt, R. (1989). Environmental impact of used motor oil. Science of The Total Environment, 79(1), 1-23. doi:10.1016/0048-9697(89)90049-1

Dutta, H. Insights into the impacts of four current environmental problems on flying birds. Energ. Ecol. Environ. 2, 329–349 (2017). https://doi.org/10.1007/s40974-017-0075-6

Fahrenkamp-Uppenbrink, J. (2015). Traffic noise effects on birds. Science, 349(6255), 1501-1502. doi:10.1126/science.349.6255.1501-c

Farmer, AM. (1993) The effects of dust on vegetation--a review. Environ Pollut. 1993;79(1):63-75. doi:10.1016/0269-7491(93)90179

Farr, D., Braid, A., Janz, A., Sarchuk, B., Slater, S., Sztaba, A., Barrett, D., Stenhouse, G., Morehouse, A., Wheatley, M. (2017). Ecological response to human activities in southwestern Alberta: Scientific assessment and synthesis. Alberta Environment and Parks, Government of Alberta. ISBN No. 978-1-4601-3540-2.

Forman, R.T.T. & Alexander, L.E. (1998). ROADS AND THEIR MAJOR ECOLOGICAL EFFECTS. Annual Review of Ecology and Systematics 1998 29:1, 207-231

Francis CD, Ortega CP, Cruz A. (2009) Noise pollution changes avian communities and species interactions. Current Biology : CB. 2009 Aug;19(16):1415-1419. DOI: 10.1016/j.cub.2009.06.052.

Fundacion Parke Nacional Aruba (2020). Policy Document: Managing Nature Conservation and High Impact Motorized Traffic. https://www.arubantionalpark.org

Google Earth. Parke Nacional Arikok. Retrieved May 21, 2020

Goossens, D., Buck, B., (2009) Dust emission by off-road driving: Experiments on 17 arid soil types, Nevada, USA, Geomorphology

Goossens, D. & Buck, B. (2014). Dynamics of Dust Clouds Produced by Off-road Vehicle Driving. Journal of Earth Sciences and Geotechnical Engineering. 4. 1-21.

Government of Western Australia (2017). Erosion and sedimentation. https://www.water.wa.gov.au/water-topics/waterways/threats-to-our-waterways/erosion-and-sedimentation

Hill, J. (2019). Jacob Hill. Retrieved 2020, from https://www.environmentalscience.org/roads

Kayode, J., Olowoyo, O., Oyedeji, A. (2009). The Effects of Used Engine Oil Pollution on the Growth and Early Seedling Performance of Vigna uniguiculata and Zea mays. Research Journal of Soil Biology, 1(1), 15-19. doi:10.3923/rjsb.2009.15.19

Khan, R. K., & Strand, M. A. (2018). Road dust and its effect on human health: a literature review. Epidemiology and health, 40, e2018013. https://doi.org/10.4178/epih.e2018013

Matsuki, M., Gardener, M. R., Smith, A., Howard, R. K., and Gove, A. (2016) Impacts of dust on plant health, survivorship and plant communities in semi-arid environments. Austral Ecology, 417: 423– 427. doi: 10.1111/aec.12328

Nieuw, X., Nieuw, C. (2020). The Effects of Off-Roading Tourism on Aruba. Organization, Governance and Management. Faculty of Arts and Science. University of Aruba.

Oosterhuis, H. J. (2016). Landscape-ecological survey of Arikok National Park, Aruba: Restoring vegetation of a dry tropical island. Wageningen. Retrieved from http://www.dcbd.nl/sites/www.dcbd.nl/files/documents/Landscape-vegetation survey Arikok NP Oosterhuis Henk Jan.pdf

Stevens, M. (2019) Off-Road Vehicle Driving and the Arid Ecosystem. UA – UCU Student Research Exchange Programme 2019

Trombulak, S.C. and Frissell, C.A. (2000), Review of Ecological Effects of Roads on Terrestrial and Aquatic Communities. Conservation Biology, 14: 18-30. doi:10.1046/j.1523-1739.2000.99084.x

UNEP (2018). Sedimentation and Erosion. http://cep.unep.org/publications-and-resources/marine-and-coastal-issues-links/sedimentation-and-erosion

Vogel, T. (2017). Human induced dust in Aruba: An assessment of the transport and spatial deposition dynamics of dust from off-road driving in Aruba and the effect of driving speed and traffic density. Wageningen.

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Fundacion Parke Nacional Aruba
26-05-2020

Webb, R.H., Ragland, H.C., Godwin, W.H. (1978). Environmental effects of soil property changes with off-road vehicle use. Environmental Management 2, 219–233 (1978). https://doi.org/10.1007/BF01866550

Examples of press articles on accidents inside Parke Nacional Arikok:

https://24ora.com/accidente-cu-quadeacer-a-laga-dos-herido/
https://24ora.com/utv-a-accidenta-den-area-di-conchi/
https://24ora.com/utv-a-pega-candela-net-dilanti-parke/
https://24ora.com/impacto-causa-pa-coremento-di-vehiculonan-tipo-off-road-riba-aruba/
https://24ora.com/quadracer-ta-accidenta-den-parke-y-un-turista-herida/
https://24ora.com/accidente-cu-herido-na-parke-arikok/
https://24ora.com/utv-cu-turistanan-a-bolter-den-parke-arikok/
https://24ora.com/turista-herida-cu-quadracer-den-parke-arikok/
https://24ora.com/accidente-den-parke-arikok-cu-turista-herida/
https://24ora.com/dama-cay-di-utv-den-parke-arikok/
https://arubanative.com/2019/04/11/un-biaha-mas-turista-ta-accidenta-cu-quadracer-e-biaha-aki-ta-den-parke-arikok/
https://arubanative.com/2020/02/25/otro-accidente-di-utv-den-parke-arikok/
https://arubanative.com/2020/01/02/quadracer-a-bolter-den-parke-nacional-arikok-dos-persona-a-resulta-herida/
https://arubanative.com/2019/11/07/dama-turista-a-accidenta-cu-utv-na-conchi/
https://arubanative.com/2019/06/20/den-mata-di-hubada-turista-a-accidenta-cu-quadracer-den-parke-arikok/
https://arubanative.com/2019/03/08/utv-a-bolter-den-parke-arikok-dos-persona-a-resulta-levemente-herida/
https://www.bondia.com/un-biaha-mas-turista-ta-bolter-cu-quadracer-den-parke/

7. Annex 1

Conservation Motivation for closing the Shete entrance to Arikok National Park on 1 April 2019

Nature Conservation

FPNA is foremost a nature conservation organization which places Nature First, to increase and maintain biodiversity and prevent impairment of park resources and values. FPNA thereby ensures that conservation is predominant when there is a conflict between the protection of biodiversity and resources, and their use.

More and more tours

Increasing pressure from more off road vehicles are having an effect on the area.

Government receiving complaints

Numerous complaints were received both by the government and FPNA regarding a lot of dust blowing into the Shete neighbourhoods.

Pollution

1. Dust (Dust effects can be seen over 200 meters away from the road)
    a. Dust blowing into neighbourhoods and affecting houses due to tour activities to from Shete to Conchi
    b. Dust clouds are covering vegetation causing harm. Vegetation is dying and area turning into a desert landscape
    c. Dust clouds negatively affects the distribution and behaviour of animals that live in the area
    d. Dust is changing soil quality in the area
    e. Soil erosion from heavily used dirt roads are going into the “rooi” systems
2. Noise
    a. Noise created by many off-road vehicles are affecting the quality of life in the adjacent neighbourhoods
    b. Loud noise negatively affects the distribution and behaviour of animals that live in the area
3. Garbage
    a. Garbage blows out of the open cabin tour vehicles into the surrounding environment on regular basis
    b. Garbage negatively affects the distribution and behaviour of animals that live in the area

Damage to dirt road

High volume of tours is causing excess damage to the dirt road resulting in:

- New roads being created by vehicles in nature areas
- Damaged roads are unsafe for visitors

Parke Arikok has 3 entrances, allowing for uncontrolled access

1. Most nature parks around the world have 1 entrance
2. Controlling access to PNA with conservation fee is more manageable with fewer entrances
3. Mitigating damage by visitor activities is more manageable with fewer entrances
4. Extra dirt roads are being created inside PNA by the many tours which causes desertification
5. Tours are being conducted after PNA operating hours due to uncontrolled access points

<u>Illegal vehicle entries are being created around the Shete area, which need to be closed again</u>
This is applicable for the entire Park border.

<u>Closing Shete road relieves stress on area</u>

1. No more dust, noise, and garbage pollution in Shete neighbourhood
2. Less nature areas within the park affected by pollution
3. Controlling access and mitigating visitor damage becomes better manageable
4. Sending vehicles through San Fuego main entrance is safer for visitors

<u>Speed limit of 20km/h reduces dust and soil erosion impact</u>