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## **My time in Aruba has been a whirlwind of wonder.**

During my stay in Aruba, I feel as if I have gone through many changes. I've come to realize what a privilege it is to be great friends with your neighbors, and to be able to meet up regularly outside of class. I am not limiting this to planned outings, as day to day interactions and small chit chat have been a blessing. My social experiences as a whole, with my fellow exchange students, and the Aruban students, have been nothing but extremely fulfilling. Academically I have also learned a lot. Firstly, not properly scheduling things is an awful mess. Secondly, reaching out to those who are willing to help is key. I used to avoid asking for help as I felt like what I was asking for would make me look foolish, and that I would be wasting others' time. Yet, I was completely open to helping others with nearly anything. This double standard that I applied to myself was a little ludicrous. I am so thankful to be surrounded by many kind and helpful people, who have enabled me to come so far. Thirdly, do not wait passively if you require information or assistance

from someone. If they are not showing signs of availability, search for alternatives. And better yet, focus on the things you still can do while waiting. I experienced several mental blocks, feeling like I could do nothing, when I clearly could have. I do not intend to let this happen again, and even if it does, I will mitigate it further. The last point I have, because it is so dear to me, is cultural, including culinary experience. Learning about the culture of the island, including the Papiamentu language was great. Trying new foods, and even attempting to cook them, experimenting, is very fun and enriching. Just recently, I made fried banana and naranjilla mixed together with cinnamon and panela to form a delectable spread. I had not been exposed too very much, if at all to naranjilla, plantain, tamarillo and other fruits, and I must say it would be a missed opportunity to not experiment with them. Going to local markets like STR agriculture farm has also been very informative, as I discovered local products such different hot sauces, and the

“Ponchi Crema”. Additionally, learning about the natural environment of Aruba has been a pleasure. Researching on my own, but also listening to people who know and are more than willing to talk about the place is great. In conclusion, I recommend to those seeking an enriching cultural, personal and academic experience to join the UAUCU program.

# Effects of Invasive Species: Impacts of *Cryptostegia grandiflora* on soil pH

Martin Soubelet

Invasive species are a problematic group of species in many parts of the world, especially small islands (Tye, 2018). Their impacts are wide ranging, affecting economies and societies as well as ecosystems and their processes. One such invasive species is *Cryptostegia Grandiflora*, invasive in many arid and semi-arid parts of the world, and often introduced for the purpose of rubber production. This paper will propose a research plan for the effects of this plant on soil, primarily concerning the island of Aruba, but may also be applied elsewhere. We will first focus on the process leading to the creation of invasive species and their impacts. Then, we will discuss the specifics of how invasive species may impact soil. After this, we will present characteristics of *C. grandiflora* and its specific impacts. Finally, we will discuss the proposed research method to study its effects on soil pH.

We begin with detailing definitions and how invasive species come to be. The current ecological model for the realization of an invasive species involves a multistep process from which a species native to an area is brought somewhere new, where it may establish and propagate. Firstly, the cycle begins with a native species, one that is within its natural range. This range can shift without the involvement of humans (IPBES, 2023). This native species may also be brought outside of its natural range, past the ecological barriers which define it, as a consequence of

human activities. It is then classified as an alien or exotic species in this new area. Ornamental and agricultural plants are common examples of such species. Of these alien species, a few may establish themselves, producing a self-sustaining population, which may begin to spread later on. There are then two paths for these species after establishment. On the one hand, they may find their own place in their new environment, without entirely replacing the indigenous species. On the other hand, they may begin to spread out of control and negatively impact native biodiversity and ecosystems. They would then be considered an invasive species, and it is believed that 1 in 1000 established species become invasive (Burg et al., 2012 ; IPBES, 2023).

We will now further detail what impacts invasive species have on the native ecosystems that they disturb. As mentioned previously, the consequences reach far and wide, and have been vastly documented in literature across a multitude of studies. We will focus on summing up a few of the most notable direct and indirect effects from the “Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services” (IPBES) report on “Invasive alien species and their control” (IPBES, 2023). Firstly, invasive species drive out native species or other alien species and can even lead them to go extinct and can drastically change biodiversity. These

species also have negative impacts for industries heavily dependent on plants and livestock, such as agriculture, thereby impacting food security. This could be from the introduction of non-native pests, or even the diseases invasive species carry with them, which also pose a threat to human and animal health (Chinchio et al., 2020). Additionally, many invasive species, being well adapted to quickly extracting resources such as water and resources, also increase water scarcity. These effects ultimately have a negative impact on human health. Secondly, invasive species can also increase the marginalization of certain activities or communities. As mentioned, activities dependent on nature are the most affected, meaning that those dependent on it the most are also the most impacted. Many groups, including migrants, indigenous peoples, poor rural communities are disproportionately affected not only by the invasive species themselves, but also by the diseases they may carry. Overall, invasive species are extremely problematic and require adequate action (IPBES, 2023). Unfortunately, current management practices have proved insufficient, and further action is needed. It is very difficult to deal with invasive species, as they generally spread quickly, a characteristic responsible for their status. Now that we have detailed the overall impacts of invasive species, we will move on to that of a specific species as a case study.

Now that we have made a general overview of invasive species, we will cover the topic of invasive plants. Given the large differences in biology between animals and plants, there are many specificities to the establishment and propagation of the latter. This next section will cover how invasive plants alter abiotic properties of the soil to benefit their own establishment. Plants are known for having an inextricable link to the soil, from which they extract the necessary water and nutrients to produce their organic matter, using their vast network of roots. The acidity, soil infiltration, water content, K, N and P levels directly affect the growth of plants. However, plants

can also modify these parameters to their advantage, facilitating their own establishment. This also naturally applies to invasive plant species. A positive change in the surrounding soil caused by a plant is known as the “island of fertility” hypothesis. This process describes multiple phenomena. Firstly, the plant produces organic matter. The leaves, fruits, and other parts may fall off and decompose, producing litter, increasing soil organic matter (SOM). This may also decrease the soil’s pH. The plant can also release protons and organic acids through their roots into the rhizosphere, directly reducing the pH. The rhizosphere is the term that describes the nearby soil whose properties may be affected by the plant. Furthermore, the plants increase fertility by depositing carbon and nitrogen rich compounds, which in turn increases the quality of the litter. Coupled together, these mechanisms improve the surrounding soil, facilitating establishment and growth of the invasive species (Souza et al., 2023). There is clear evidence that *C. madagascariensis* fulfills this hypothesis. It has been shown to have decreased pH, and increased contents of phosphorus and nitrogen in invaded environments (Souza et al., 2015, Souza et al., 2023). In Brazil where Souza et al. carried out their studies, they have shown that the native litter was in fact less fertile than that of *C. madagascariensis* (Souza et al., 2023). It is therefore worth investigating if *C. cryptostegia* does the same.

This paper focuses on one invasive species in particular, *Cryptostegia grandiflora*. *C. grandiflora* is a species of what is commonly called “rubber vine”. It is also known as Cordon di San Fransisco in Papiamentu. It is a woody perennial vine native to Madagascar and parts of tropical Africa (Burg et al. 2012; Tomley, 1995). As previously mentioned, the genus also has another species, *Cryptostegia madagascariensis*, native to Madagascar as well (Tomley, 1995). It has elliptic leaves that are glossy green and its flowers are pale pink and white, seen in figure 1 below (Cordon di San Fransisco ; Tomley, 1995).



Fig 1. Photograph of *C. grandiflora* By Forest & Kim Starr (CC-BY)

Its many stems intertwine with each other, or with a host plant allowing it to climb high and form large thickets. This plant is also able to spread rapidly, growing up to 5 meters a month in the rainy season, and release a great amount of seeds at once (Burg et al., 2012 ; Cordon di San Fransisco). It is quite hardy and stress tolerant, able to grow in a very wide range of soil conditions. *C. grandiflora* is invasive in many semi arid to arid parts of the world, including but not limited to Australia, Ethiopia, Mexico, the United States and the Caribbean (Burg et al., 2012, Luizza et al., 2016 ; Rodríguez-Estrella, 2010). It is quite problematic in all of these areas. It is known for forming large thickets covering all vegetation, reducing accessible sunlight (Luizza et al., 2016). *C. grandiflora* can also quickly outcompete natives and form monospecific stands especially in riparian areas, as it has been observed in Baja California, Mexico (Rodríguez-

Estrella et al., 2010). It has also had negative consequences on domestic livestock production, as the animals depend on these riparian areas for food (Kriticos et al., 2003). In Australia, it has also been shown to have severely changed fire regimes, “promoting frequent crown-fires” (Luizza et al., 2016, Radford et al., 2008). Further, because it is so competitive in arid environments, it extracts what little water is present there, leaving native species under more stress. Overall, it has been shown to reduce native biodiversity and species richness (Luizza et al., 2016). These impacts are also predicted to become widespread, as the distribution of *C. grandiflora* may increase with climate change (Kriticos et al., 2003). As for the lesser Antilles, especially Aruba, research on its impacts has been sorely lacking. Indeed, the only research paper associated with this plant and Aruba is a report from the University of Wageningen, Burg et al. 2012. Neither is there any data present in Aruba’s own national archives (Coleccion Aruba), or the public archives of the Directorate of Nature and Environment. Descriptive information can be found in “Arnoldo’s Zakflora. Wat in het wild groeit en bloeit op Aruba, Bonaire en Curaçao.” by Ketner P., which is a book detailing the flora of the ABC islands, as well as in the Aruba National Park Foundation Fact sheet on the plant (Cordon di San Francisco).

Now, we will detail a research proposal with a relatively simple protocol to study the impact of rubber vine on soil pH. Preliminary observations, as well as discussions with the National Aruba Park Foundation indicate that *C. cryptostegia* is primarily found in disturbed areas, along roads and water runoff passages. It is also found around “cactus fences”. One can often find parallel rows constructing a path in the middle. According to a member of the Department of Agriculture, Livestock and Fishery of Aruba, these fences were grown for the purpose of creating safe paths for traveling, as well as fencing of private property. By driving through Aruba looking for rubber vine, 28 sites were established. The site coordinates where the rubber vine was found were recorded and input into google maps.

They are displayed in the map below:

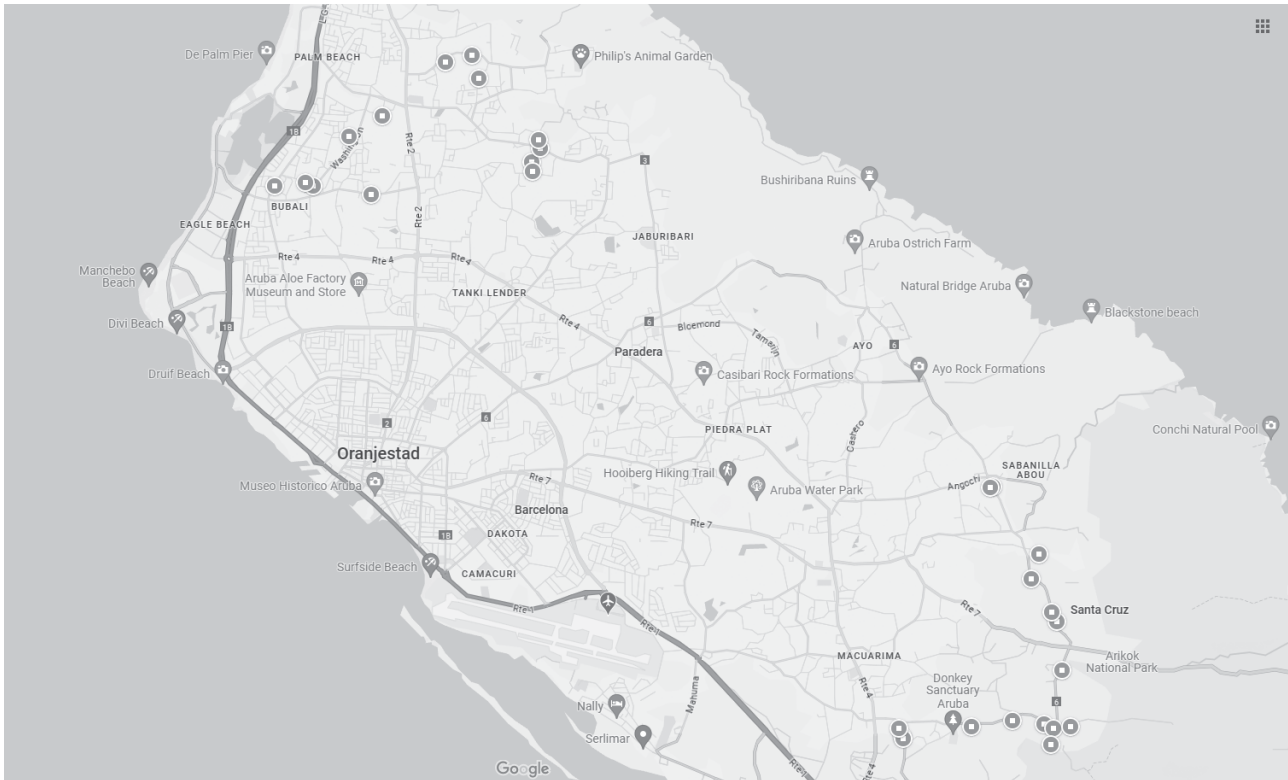


Fig2. Map of *C. grandiflora* locations in Aruba. A marker symbol consisting of a circle with a square in its center indicates the presence of *C. grandiflora*.

After identifying locations of rubber vine, plots must be defined. This research is structured around paired plot design. That is, for each plot that is invaded by rubber vine, another plot was drawn nearby with similar conditions without rubber vine. This enables a comparison to be made allowing to determine whether rubber vine has effects on the soil. It is important that other conditions such as soil type and the type of environment (e.g. dry shrubland, forest, proximity to roadside etc.) be considered to reduce

confounding factors. The main factors controlled were soil type, litter quantity, ground and tree cover (species and approximate density). Due to time limitations, these controls were done through visual observation only. Species were not all identified, but parity of species between plots was ensured. Proper cover measurements as well as soil texture tests are recommended. Each plot may be 2x2 m, and the ones containing invasive species should be centered around a rooting stem. This size is chosen as the thickets

range greatly in size, and may be extremely small, as well as some sites being near cactus fences, which present a physical boundary. In each plot, a trowel was used to take 3 random samples, from 0 to 10 cm depth. A trowel was used as the soil was much too dry to use a soil core borer. Indeed, the soil would simply fall back into the hole that was bored. Place the samples in a plastic bag. Each plot must have the texture of the soil tested to ensure proper parity. One possible method is the bolus and ribbon test. Soil is moistened and kneaded into a ball. The soil to water ratio is then adjusted until the soil just “fails to stick to the fingers”. This soil ball, or bolus, is then pressed into a ribbon. The length and width of the ribbon can then be evaluated to determine the soil type, following a flow chart (Commonwealth Scientific and Industrial Research Organisation, 1997). As mentioned previously, this test was not able to be put into practice. Soil type parity was assessed by comparing samples visually and through touch. After collection of the soil, bags were left open to dry for a minimum of 24 hours, to ensure that the samples were dry. Were this research to be carried out during the wet season, higher drying times may have been required. So far, 8 samples were taken at 4 sites. 10 sites and 20 samples is the current objective. This concludes the research carried out. The next paragraph describes the following steps for this research.

After collecting the soil samples, pH will be tested. 10 grams of soil will be mixed with 25 ml of distilled water in a beaker. The contents will be stirred for 10 minutes using a magnetic stirrer. Then, leave the contents to settle for another hour. This will allow the separation of a liquid and solid phase. Some of the liquid will be transferred into another beaker using a pipette. Finally, a calibrated pH meter will be used to finally measure the pH of the liquid phase. This protocol is based on the international standard, ISO 10390-2021. For statistical methods, paired design tests will be used. There are of course limitations to this field method. Seasonal variations, as well as local varying disturbances may affect

the properties of the soil. The results will provide further insight on what effects *C. grandiflora* may have on the soil. Additionally, because of the lack of robust measurements of plant cover and soil type, parity between sites may also be affected to some degree. Further research should be carried out to also look at the organic properties of soil, such as the microbiome, which is still not fully understood.

In conclusion, invasive plant species are a worldwide problem with far reaching negative impacts. They directly affect native biodiversity, and all those who depend on it, including various animals, and of course, humans. Invasive plants can increase the fertility of the surrounding soil around them to their own benefit. It is then proposed to investigate if a species of rubber vine, *Cryptostegia grandiflora*, can affect the soil abiotic properties, notably pH.

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