Introduction to the
Geography, Geology, Climate and Flora Habitats
of Villa Mi Terruño & Culebra, Puerto Rico

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Introduction

The experience of appreciating the subtropical Flora and Fauna of Culebra affords visitors and residents a unique opportunity to enjoy a very special personal experience of both a visual, personal and spiritual dimensions. Nature is a God given gift to be enjoyed today, shared, and conserved for our future generations.

The FMT Culebra Flora and Fauna Digital Photographic Databases are published by Fundación Mi Terruño, Inc. (FMT) with special permission and license from its author and amateur photographer, Manuel H. Dubón. The database presents and describes the flora found within the land site of a proposed 30 acre sustainable resort-residential development of advance design designated as Villa Mi Terruño (VMT). The database has been expanded to cover the general flora of Culebra. FMT publishes this photographic website to offer Culebra residents, our island visitors, guest from Puerto Rico or afar and website visitors a visual and learning experience as they observe and enjoy the Flora of Culebra in its entire splendor.

The site will hopefully enrich the visitor’s and resident’s life experience as they appreciate and learn to better understand the dry subtropical forest environment in the Caribbean island of Culebra. The Flora Digital Database will also allow website visitors, students and professional and amateur naturalist to do research or read and enjoy the essays and the specialized photographic database of the tropical species of the Flora of Culebra with ample digital research references.

To date the digital database of the Flora of Culebra is the only specialized and organized flora photographic database available in the web of Puerto Rico flora. Except for a number of introduced exotics or established non-endemics, the species described in the database are designated, for plant classification purposes, as subtropical Caribbean dry forest flora and form part of the universe of the Flora de Puerto Rico and of the much larger Flora of the Master Puerto Rico Geological Platform Bank. No other specialized organized HMTS web database published in Puerto Rico has been found for the Flora of Puerto Rico other than informal sights that have some photographs or tourism general descriptions. A few that have some specialized organized flora indexes or PDF and some with more formal photo presentations of general Puerto Rico flora.

In the subdirectory of the web site, http://www.villamiterruno.com/florayfauna.php you will be able to enjoy a unique digital photo database, essays and digital classified pictures and Microsoft PowerPoint © presentations on the Flora of Culebra. The database is subdivided into two sections: (1) the Flora of Culebra Digital Photo Database, which is under continuous
update, and (2) the Fauna of Culebra Digital Photo Database. The Fauna of Culebra Photo Database is not ready for publication and will be incorporated to the site at a much later date.

The FMT Culebra Flora Digital Database photographic and classification directories and subdirectories facilitate handling and searching of the data by summarizing in five distinct Microsoft Excel© master indexes, site plant catalogue or lists of the taxa or plant species found in the database and its content to assist with its use. The directories were created to assist in better understanding the universe of identified species and to establish a master regional flora cross reference of the subtropical in the neighboring islands to the east that form part of the Puerto Rico Platform region to assist in classification. The first two indexes designated as Master Puerto Rico Geological Platform Bank Indexes classify and list the larger universe of flora plant found in the Puerto Rico Platform that extends offshore from the eastern geographic limits of the island of Puerto Rico to the island of Virgin Gorda and Anegada in the eastern end of the British Virgin Islands. The other three indexes, the FMT Culebra Flora Digital Database Indexes, are specific to Culebra and its cays including Culebrita, a small ecologically protected island east of Culebra. They are organized in three separate searchable plant lists or Excel databases both in (1) plant alphabetic scientific name format, (2) plant family name format and (3) type of plant format. For more information see the presentation in the Instructions subsection entitled Use of the Database and Digital Material and Indexes or visit http://villamiterruno.com/uploads/VMT_Website_Flora_Summary.mhd.v.14.1.052214.pdf, a short bilingual genral introduction to the site found in this section of the Villa Mi Terruño Digital Web Site. The Flora of Culebra Digital Photo Database and its indexes have already grown, as of October 15, 2016, to 550 identified species or taxa. Most of the VMT flora is also generally prevalent and found outside VMT’s boundary in Culebra. A great amount of time and effort have been spent by its author over the past few years photographing, identifying the plants and assembling them into this organized database for your enjoyment. It is a love of nature and committed dedication to study and acquire knowledge. FMT and the author will greatly appreciate any corrections or enhancements to its content.
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The Geographic Location and General Description of Culebra Island

**Culebra, Puerto Rico** is a very small Caribbean tropical island located to the east of **Puerto Rico**. It forms part of the island archipelago of the eastern platform belt of the **Greater Antilles Arc** in the **West Indies**. **Culebra** has one inhabited main island and 23 smaller uninhabited offshore cays of exceptional beauty and natural attractions. The island enjoys a temperate subtropical climate refreshed during the day by the northeastern trade winds. Its seasonal and limited rainfall establishes Culebra as a dry subtropical forest ecosystem. Only certain plants can naturally immigrate, establish and reproduce themselves in the specific life zones or selective microclimates. Its three largest keys are **Culebrita**, **Cayo Norte** and **Luis Peña**. In appearance they resemble Culebra in that all have rugged coastline, cliff and gentle to steep hills, sandy beaches and vegetation in the moderate to extreme dense coverage densities. The smaller keys have no or sparse vegetation covers. They are primarily solid rock all around with a rugged coast and in some tiny beach areas may be found when the seas are calm.

It is located 18 degrees and 19.01 minutes north of the Equator and 65 degrees and 17.24 minutes west of the Prime Meridian. **Culebra** island lies approximately 27 km or 17 miles east of the “big” island of **Puerto Rico**, approximately 19 km or 12 miles west of **St. Thomas, U.S. Virgin Islands (USVI)**, and approximately 14 km or 9 miles north of the island of **Vieques** all on the **Puerto Rico Geologic Platform** of the **Northeastern Geologic Platform Bank of the Greater Antilles Arc**. The **Puerto Rico Platform** extends from the western end of the island of **Puerto Rico to the USVI and British Virgin Islands (BVI) to the East**. Like all islands in the **Puerto Rico Platform, Culebra** and its adjacent keys form part of an arc of island underlain by volcanic and intrusive rocks formed during the **Pleistocene period**. The dominant topographic features of the **Isla de Culebra** are the two hill ranges in the north side and south side of the island. The northeast range is wider and trends from the northwest to northeast while the other trend from the southwest to the south east. The two dominant scenic ranges are separated in a U shaped manner by a large navigable inner inlet known as **Ensenada Honda** which divides the island into a north side and smaller south side. For these features **Culebra** is often described as being shaped like a lobster claw, a **Maine** Lobster claw. The lobster claw has its base at **Punta Molinos** point in the **Flamenco Beach Peninsula** in the northwest corner of **Culebra**. It extends in a east-southeast direction to form the wider, upper larger claw half over the northeastern dominant hill ranges of the island. The **Ensenada Honda Inlet** bay in the center, establishes the open area of the claw. It then splits and continues to the southeast past the town of **Dewey** over to the **Punta Soldado** peninsula-like south extension of the island to form the thinner lower claw half.

The island is very picturesque with integrated views of the sea, land and green hills, with beautiful coves and beaches and blue skies with white clouds. It has some of the most beautiful and internationally recognize beaches such as **Flamenco Beach** and **Culebrita Beach**.

**Culebra** is approximately seven miles long by five miles wide (11 km by 8 km) and occupies an area of approximately 11.6 square miles or 28 square kilometers. It predominantly has shallow shoreline
coastal zones behind its beaches that rapidly rises from steep coastal cliffs to a hilly topography. Its highest hills are Monte Resaca with an elevation of 650 feet (198 m) and Cerro Balcón with 541 feet (134 m) on the north side. The central hill of the VMT parcel is the highest elevation point on the southern side of the island, in the Playa Sardinas II Ward, with an elevation of 350 feet (107 m).

The island is divided into six wards; Dewey, Flamenco, Fraile, Playa Sardinas I, Playa Sardinas II and San Isidro. The island and its cays have an approximate area of 7,700 acres or some 6,747 cuerdas. Cayo Luis Peña has 315 acres, Cayo Norte 303 acres and Culebrita 266 acres and 69 in the smaller cays. Including Cayo Luis Peña and Culebrita. The Federal Government had title to 34.7 % of the lands in Culebra until the US Navy ceased operations. In 1977 the US Navy declared in excess of its needs 1,346 acres, these included the Island of Culebrita, a USFWS reserved today, 286 acres around the airport, 177 acres on the southern end of the Fulladosa Peninsula and the coastal strip around the northeastern, eastern and southern coast of Culebra.¹

Culebra was discovered by Columbus on his second trip to the new world. It was the last offshore island of Puerto Rico to be colonized and inhabited during the Spanish colonial period. It was originally inhabited by the Taíno Indians. The Indians were displaced and the island remained uninhabited during most of the European 400 year colonization period. It was occasionally used by pirates who found shelter in its protected harbor, as well as by fisherman and sailors. During this period, it was known as the “Isla del Pasaje” (Passage Island). In October, 1880, Culebra was finally first settled by means of land grants. After its first settlements, the island became known as “Isla de San Idelfonso” in honor of the Bishop of Toledo, Spain. It later became known as Culebra one of the last names of the first administrator. After the Spanish-American War, from the early 1900s until 1975, most of the northwestern half of the island, including the world ranked Flamenco Beach and its cays, were used by the U.S. Navy for target practice and naval exercises. It remoteness, limited water supply and use by the Navy during the first three quarters of the twentieth century protected the island from development other than the limited grazing agricultural use in the southern and eastern ends.

Culebra is of volcanic origin and characterized by steep hills, sandy beaches, reefs, small islands, bays, and coves or inlets “ensenadas” like Ensenada Honda and Ensenada Fulladosa. Culebra has a National Marine Reserve known as the “Canal Luis Peña Reserve”, located to the west coast between the Flamenco peninsula and Punta Melones to the north and Luis Peña Island to the south.

Culebra’s local environmental and species habitat conditions reflect the island’s West Indies location including the gradients of elevation, longitude, and latitude and the multitude of micro-scale physical and chemical factors that vary within these gradients. Moreover, the local environmental and cliff seashore and hilly land contour conditions of the island constrain the patterns of land use and plant establishment and habitation.

Alternatively, the constraints of its local conditions provide opportunities to use existing ecological patterns and processes as models for efficient and sustainable land use. The different rates of its key ecosystem processes, such as primary production and decomposition, are limited by soil nutrients, temperature, and water availability. The temporal pattern of availability of these factors, as mediated by climate and weather, are presented in another section that follows entitled Zone of Life (Humidity, Elevation and Diversity).

Thus Culebra’s geographic and geology local reality will only allow certain ranges of natural ecological-process rates without artificial continued management inputs. External and human intervention may broaden these ranges but cannot entirely evade the constraints of place. For instance, the proposed interaction with the sustainable development proposed on the Villa Mi Terruño “VMT” site maintains the undisturbed green areas and ecosystem process by enhancing productivity on the more sensitive vegetation covered areas and improving the evapotranspiration rates and filtration of water and nutrients to the soil.

Through programmed reforestation more plant species are planned to be planted in the VMT area. Proposed additional reforestation with current established dry forest species enhances and increases the number of species and their long term survival. Exotic species introduced in the area could affect the natural count of naïve species, so it should be taken under consideration when planning the planting layouts and managed with the introduction of restrictive covenants.

Agricultural (seeding and other modification on the plants, landscape or others) production requires favorable conditions of temperature, soil, nutrients, and water, key limiting factors for plant growth and productivity. The temporal pattern of these factors is a consequence of climate and weather, restricting the location of agriculture and the suitability of particular crops. Using plants appropriate for a particular place and situating agricultural and natural patches of vegetation in an appropriate landscape context can allow sustainable communities and better land use, reduce the impacts of developments on adjacent areas, and permit more efficient use of resources. Many uses of land have failed in the past in Culebra because species composition and ecosystem processes have not been appropriately matched with the local physical, chemical, and climatic conditions.

The Flora Study Area of the Eastern Geologic Platform Bank of the Greater Antilles Arc

To better appreciate and enjoy our focus or study area of the FMT Culebra Flora Digital Photo Database, we must first look back over millions of years to get a better understanding of Culebra’s geological formation and its relative location in our planet. The digital photo database covers a very small and specific subset of the universe of subtropical plants in our world. Culebra does not exist by itself, its forms part of a group or universe of related islands that have suffered similar geological processes. We must first understand and place ourselves in the Culebra subset of the flora universe.

The user of the Flora of Culebra Digital Photo Database will first find two flora indexes in alphabetic and taxonomic family format that describes and catalogues the Flora of the Puerto Rico Northeastern Geologic Platform Bank of the Greater Antilles Arc, also known as the “Puerto Rico Platform”. These
two master database indexes establish a base subset of the vascular plants taxonomic universe of the Puerto Rico Platform islands and cays within the West Indies Flora and the tropical vascular plants general universe. These indexes list, as of September 30, 2016, the currently accepted scientific names of some 1,529 plant species or taxa of vascular plants from the Puerto Rico Platform islands, including taxonomy and distribution by island. These master indexes focus on the botanical names of identified flora found in the geographic island belt zone that starts at Icacos Island, off the eastern coast of the main island of Puerto Rico, and continues in an eastward direction to the end of the Northeastern Greater Antilles Arc in the island of Anegada in the BVI.

The Department of Botany of the Smithsonian Institute publishes in the internet a Catalogue of Seed Plants of the West Indies (“SI Catalogue of WI”). In this site we find a flora index of the West Indies, [http://botany.si.edu/Antilles/WestIndies/checklist.htm]. The site has listed and classified for Culebra 56 genera (family) and 224 taxa (species) records of flowering plants as of July 14, 2015. [http://botany.si.edu/Antilles/WestIndies/results.cfm?formid=Culebra] The SI Catalogue of WI is the most specialized subset index of flora species of the Northeastern Geologic Platform Bank of the Greater Antilles Arc. These specialized indexes and catalogues provide the amateur and professional biologist with a subset of the identified and published plant universe of the islands. The United Sates Department of Agriculture “USDA” Plant List, [http://plants.usda.gov/dl_state.htm], combines the island subsets in two mayor categories to provide a larger subset for each of Puerto Rico and the US Virgin Islands. The USDA internet site has in addition listed and classified for Culebrita 11 genera and 14 taxa of flowering plants. No such combined subset is presently available for the British Virgin Islands. Some of the species appear in both the Smithsonian, USDA plant lists and plant list of books and other publications.

This master core plant list has been enriched by the Flora list of three EIS Flora and Fauna Studies conducted on behalf of the US Corps of Engineers by the Ellis Environmental Group, LC on Cayo Lobo in September, 2006, Cerro Balcón in August, 2006, and on Culebrita in November 2006 and the recently published Article on the Rediscovery of Eugenia Fajardensis.² It has also been enriched by the List of Vascular Plants or Flora Guanae published by James Lazell in his book Island³ on the fauna and flora of Guana Island, BVI. Newly identified native plants and introduced xerophytic exotic plants identified by the author in Culebra are also added to the master lists. All these plant lists include the flora species or taxa of the vascular plants of the geographic platform that extends east from the offshore islands of Vieques, Culebra, Icaco, Palomino and Culebrita that are part of Puerto Rico, sometimes also referred

² Trejo Torres et al. Recovery of Eugenia fajardensis (Myrtaceae), a Rare Tree From the Puerto Rican Bank, Phytotaxa 191 (1):154-164 [http://dx.doi.org/10.11646/phytotaxa.191.1.10]

as the *Spanish Virgins*, next, it continue east to the *US Virgin Island* with the flora of *St. Thomas* and *St. Johns*. Finally, it extends east again to the *British Virgin Islands* with the flora of *Jost Van Dyke*, *Tortola*, *Guana*, *Virgen Gorda* and lastly *Anegada*, the last outpost of the *BVI*. *St. Croix*, to the south in the *USVI*, is excluded from this master index for the island was an independent vertical outcropping formation from the ocean floor separated from the the other US Virgin Island by a deep channel that did not form part of the historical process of volcanic formations and settlement of the *Puerto Rico Northeastern Greater Antilles Arc* of islands. *Puerto Rico’s* mainland *Si island general* flora index, which contains some 3,100 records, is not incorporated due to the fact that the smaller offshore islands of the *Puerto Rico Platform* have a narrower band of life zones and taxa composition. These master subset indexes contain some 1,529 records of identified plants as of September of 2016. The master subset lists facilitates the study and classification and identification of unknown plants found in *Culebra* and other islands by offering the user the advantage of examining a master universe of identified species already identified in the area classified by species families.

**Puerto Rico Northeastern Geologic Platform Bank of the Greater Antilles Arc**

[The Geologic Platform Boundary is the Contiguous 200 meter Contour from Puerto Rico to Anegada]

**“The Puerto Rico Platform” Tropical Flora Universe Area**
**Plant Distribution and Establishment:** Vascular plant distribution in our planet is regulated by abiotic or nonliving components of the biosphere and biotic or living organism factors of their spatial habitat. Ecosystems are structured and made up of interactions between their living and nonliving components. Plant distribution is highly dependent on sunlight and other climatic conditions to establish themselves, and propagate. Climate seasonality and extremes in parameters such as weather patterns, sunlight, temperature, precipitation, humidity, evaporation, solar radiation, cloud cover and cloudiness greatly determine plant species growth and habitat. Geologic conditions and terrain factors, such as topography, mineral content and gradient patterns, height of hills and mountain and its proximity to ocean coast, land formation and development, and its rock and soils patterns, depth, stratification and the nutrient and mineral content are also very important growth variables. Biotic factors, processes and interaction of other living plants and animals such as dispersal, facilitation, mutualism, dispersion patterns, competition, and predation, among others, including human intervention, pollution and climate change all continue narrowing the dispersal, establishment, survival, reproduction extinction band of vascular plants in our planet. The natural processes and environmental regulator of life in a specific Life Zone are determined by species content, competition and adaptation. They have biotic and deterministic consequences on species distribution which, when all is taken into account and processed, leaves a narrow belt or “fundamental niche” where a plant can grow, disperse and survive in our planet.

The **unifying factor** of the entire island arc area of the **Puerto Rico Platform** is, as discussed in the next section, is that it once formed a single land mass with the **Puerto Rico’s main island.** The integration and interchange of flora between islands was significant during these cyclical reunified island and single land mass periods and thereafter by other means of dispersion including waif dispersal and storms. “Waif dispersal is long-distance movement of organisms across a barrier of inhospitable habitat that results in the establishment of a new population.”

This interchange was naturally regulated by the natural barriers of the different receiving climatic life zones that generally delimited the species that could survive in a specific life zone and particularly in the **dry subtropical forest habitat life zone** prevalent in throughout **Puerto Rico Platform.** Only certain

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4 Vascular plants (also known as tracheophytes or higher plants) form a large group of plants that are defined as those land plants that have lignified tissues (the xylem) for conducting water and minerals throughout the plant. They also have (non-lignified) tissue to conduct products of photosynthesis. http://en.wikipedia.org/wiki/Vascular_plant


7 Ibid
plants could naturally establish themselves in the specific life zone or selective microclimates such as those found in the higher elevations of hills and higher mountains in some islands (i.e. tropical rain forest) or in mangrove and other wetland coastal areas found in the different islands and cays. Some islands because of the height of the hills or mountain or specific different or wider array of microclimates can sustain a different set of plants, as for example, those that may be found in a tropical rain forest. Culebra has a narrower subset of variables due to lower hills and limited territorial mass. Culebra has a narrower subset of variables within its dry subtropical forest life zone due to its lower hills, the absence of rivers, shallow soils, an extended dry season and limited territorial mass.

**Geological History of the Northeastern Geologic Platform Bank of the Greater Antilles Arc:**

The geological history of the Northeastern Geologic Platform Bank of the Greater Antilles Arc dates back over 120 to 135 million years to the late Cretaceous periods.  

During these periods, the North American Plate, located to the north of Culebra and Eastern Caribbean, subducted in a southwesterly direction beneath the Caribbean Plate located across to the south of the island belt. After this major collision of the Cayman Trough in the Bahamas with the North American Plate, some 49 million years ago, the subducted relative plate motion of both the North America and Caribbean Plates changed to a more easterly direction (~250°), resulting in a cessation of arc volcanism and in a highly oblique plate subduction dynamics with a large component of bilateral strike-slip. This major uplift strike shift caused the Greater Antilles volcanic strata to rotate to a nearly vertical position with the earliest rocks being found in the southwestern islands and the youngest rocks being found in the eastern end of Tortola and the BVI chain. In this sector of the Caribbean the uplift and shift exposed the batholiths of molten volcanic rock which upon being exposed and cooled, created igneous rock strata with intense crystallization and metamorphism of the surrounding rock strata.

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8 Wikipedia defines it as “derived from the Latin “creta” (chalk), usually abbreviated K for its German translation Kreide (chalk), is a geologic period and system from circa 145 ± 4 to 66 ± 0.3 million years (Ma) ago. In the geologic timescale, the Cretaceous follows the Jurassic period and the Cretaceous is followed by the Paleogene period of the Cenozoic era and early Tertiary.” Wikipedia also defines it “as period began with the demise of the non-avian dinosaurs in the Cretaceous–Paleogene extinction event, at the start of the Cenozoic Era, spanning to the beginning of the most recent ice age at the end of the Pliocene Epoch. The Tertiary also included the early Pleistocene” http://en.wikipedia.org/wiki/Cretaceous

7(See Brink, Marshack and Granja-Bruña, Geologic Society of A. Bulletin, Nov./Dec/, 2009 p. 1524)
The Puerto Rico Platform, by itself, is independently dynamic. We quote from Lazell’s excellent summary: “Recent evidence is that virtually all rotation of the PRVI (the Puerto Rico Platform) ceased four or five million years ago (Jansma et al. 2000) remarkably coincident with the closure of the Isthmus of Panama in the Pliocene. Jansma et al. (2000) discussed evidence that the PRVI block is undergoing “teutonic escape,” from between the Caribbean and the North America plates, going east, “squeezed like a pumpkin seed.” This scenario was proposed for several edge microplates or terraces by Roughgarden (1995)11, but was unsupported by the geologic evidence when that [proposed scenario] was carefully reexamined. (Perry and Lazell, 1997 and references therein)12. Similarly Jansma et al. (2000) reject this notion: they conclude that the PRVI block “is attached to the Caribbean at its eastern end” - that is, the BVI- precluding eastward teutonic escape”. The preclusion of teutonic escape certainly contributes to buckling, folding, and faulting. Although all of this may not cause earthquakes with epicenters among the islands, the quake that occurred off-shore can cause spectacular tsunamis – seismic sea waves – like the one that rolled ashore in the Virgin Islands in 1867 (Reid and Tabor 1920)13e.

(Lazell, 2000, p. 106)

All the undersea mountain-building and volcanism and the highly oblique plate subduction with the consequent uplift and shift that exposed the batholiths of molten volcanic rock subsided, and centuries of coral building and sediment accumulation was followed with significant periodic changes in sea level over the last 22,000 to 10,000 years. The periodic sea level changes were caused by the thermal expansion of warming water, glacial and polar ice melts and vice versa during the planet’s cooling and warming cycles. The rise and falls of sea level during these historic periods climatic changes produced sea level fluctuations from 120 to 130 meters (400 to 425 feet) below the present coastal water level of the islands and cays of the Puerto Rico Platform. In general, all known land areas separated by sea level changes shallower than 120-130 meters below our present sea level should have been continuous with each other at glacial maximum during these historic periods.14 Climate also affects ambient ocean water temperatures and it’s high and low extremes, as well as consequent rainfall and micro climate changes of ecosystems and its habitats.


14 Lazell,2005, Ibid. p. 115,
All of the land masses of the northeastern platform arc were formed during the Pleistocene period and assembled into a single mass with the main island of Puerto Rico above water before finally becoming, after the many glacial cycles, the separated current group of islands and cays we know and visit today as the Spanish Virgins, US Virgins and British Virgin islands. The principal US Virgin Islands, St. Thomas, and St. John and Culebra lost their connection with each other and to Puerto Rico only about 8,000 to 10,000 years ago due to eustatic rise in sea level. Vieques, Caja de Muerto, and many small cays and islands remained connected to mainland Puerto Rico until 6,000 years ago.

Let’s conceptualize what this all means. When we next examine the navigation maps of the Puerto Rico Platform, we discover that the present depths in fathoms among the separate islands from Puerto Rico to Anegada generally varies only from 10 to 30 fathoms in the deeper areas beyond the surrounding shallower seas. The Planet’s climatic changes caused fluctuations from 120 to 130 meters (400 to 425 feet) below the present sea level of the islands and cays of the Puerto Rico Platform that translate to changes from 66.6 to 70.8 fathoms. Thus most inter-island connections today occur from the 10 to 25 fathom depth range with many below 20 fathoms. This present inter-island depth separation and connectivity range translates to depths from the 60 to 150 feet range with many below 120 feet to be able to have most if not all of the islands interconnected. We can then conclude that if present water depth levels were 120 feet lower, most, if not all of the islands should have continued interconnected. In climatic change fluctuation cycles of sea level raises and falls of 400 to 425 feet from present sea levels, this means that during the long raising and lowering sea level

15 Ibid.

16 1 fathom = 1.8288 meters or six (6) feet

17 Lazell, 115
cycles, the islands should have been interconnected throughout most [approximately 66%] of the fluctuation cycles of raising and lowering sea levels he 12,000-year Glaciation period.

Let’s next project the most likely impacts of these changes. If we can imagine the condition of present day land features during their longer periodic glaciation cycles of highest connectivity, when water levels were below 120 feet, then we can imagine the hill ranges in Culebra changing from the present 650 feet height of Monte Resaca up to 1,025 feet above sea level and back. Similarly, the highest hill of the Playa Sardinas II Ward, where VMT is located, would have risen up to 775 feet during low maximum. These resulting higher hills would have created larger drainage and vegetation basins, valleys, mangrove areas, and micro-climate habitat areas due to the changes in water levels and climate. For example, the higher hill would have caused more orographic rainfall in the Puerto Rico Platform. The nature of the prevailing Caribbean easterly trade winds would have had a noticeable limitation in species establishment, since predominantly easterly flowing winds would have limited seed dispersal from the larger Puerto Rico land mass areas most of the time. Only during seasonal reversed wind patterns that blow from the northwest and southwest could seeds have been transported by winds.

The central question is when was the last time that this habitation process stabilized enough to permit species long-term establishment and habitation in Culebra? It was only after the latest glacial cycle, some 8,000 to 11,000 years ago, that the conditions needed for a stable temperate zone, climate, and humidity became available and a defined life zone materialized. The principal U.S. Virgin Islands of St. Thomas and St. John, and Culebra, lost their connection with each other and to Puerto Rico only about 8,000 to 10,000 years ago due to this eustatic rise in sea level. Vieques, Caja de Muerto Isle off the coast of Ponce, and other small cays and islands, remained connected until 6,000 years ago. Planetary stabilization finally arrived and allowed the dispersal, establishment and reproduction that developed into the currently known flora and fauna populations on these islands of the Puerto Rico Platform.
The Holocene period, as we can appreciate from the table above, has been a relatively stable climatic period as compared to the prior Pliocene glacial and interglacial period. Since some 12,000 years ago temperatures over central Greenland has been raising overall from the -30°C to the -20°C the last major colder cycle ending some 8,200 years ago when it decreased to -35°C.

Ocean temperature in the Sargasso Sea, the area of the North Atlantic from the Azores Islands to the Greater Antilles (35° to 20° N) has fluctuated from 25.4 °C to 22°C (35° to 20° F) during the past 3,000 years. During the “Medieval Warm Period”, which lasted from AD 950 to 1250, temperature remained in the 23.5°C to 22°C range. Temperature have remaining in the 23.5°C to 22°C range within the last 500 year from the end of the last “Little Ice Age” when temperatures last decreased to 22°C (1°C) some 300 years ago after which temperature started to raise to the present temperature of 22.7°C. Temperatures during this current cycle are expected to continue a little over 2°C.

“Since that early century warming, temperatures have raised well-beyond those achieved during the Medieval Warm Period across most of the globe. The National Academy of Sciences Report on Climate Reconstructions in 2006, found it plausible that current temperatures are hotter than during the Medieval Warm Period. Further evidence obtained since 2006 suggests that even in the Northern Hemisphere where the Medieval Warm Period was the most visible, temperatures are now beyond those experienced during Medieval times (Figure 1). This was also confirmed by a major paper from 78 scientists representing 60 scientific institutions around the world in 2013.”

18 The Holocene /ˈhɒləsiən/ is the geological epoch that began at the end of the Pleistocene[1] (at 11,700 calendar years BP)[2] and continues to the present. The Holocene is part of the Quaternary period. Its name comes from the Greek words ὅλος (holos, whole or entire) and καινός (kainos, new), meaning "entirely recent".[3] It has been identified with the current warm period, known as MIS 1, and can be considered an interglacial in the current ice age based on that evidence. https://en.wikipedia.org/wiki/Holocene


20 Bradley, Raymond S. & Jonest, Phillip D., 'Little Ice Age' summer temperature variations: their nature and relevance to recent global warming trends, The Holocene, December 1993, vol. 3no. 4 367-376
Figure 1: Northern Hemisphere Temperature Reconstruction by Moberg et al. (2005) shown in blue, Instrumental Temperatures from NASA shown in Red.

To the north of the Puerto Rico Platform is the Puerto Rico Trench, which includes the deepest part of the Atlantic Ocean, with depths exceeding 8,400 meters. Unique plate convergence activity takes place in this sector of the planet.

The image above is from the Caribbean earthquake and tsunami hazards studies page of the USGS’s Woods Hole Science Center.

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21 Anders Moberg1, Dmitry, M. Sonechkin, Karin Holmgren, Nina M. Datsenko & Wibjörn Karlén, Highly variable Northern Hemisphere temperatures reconstructed from low- and high-resolution proxy data, Nature 433, 613-617 (10 February 2005)
The North America Atlantic Plate meets the Puerto Rico Trench with a resulting oblique convergence-subduction, thus continuously moving under the platform, with a left lateral strike slip faulting. This subduction causes a movement from the northwest at about 11-17 mm per year in an eastward direction with a resulting 6-8 mm northward movement of the PRVI platform microplate. However to the south of the platform the Caribbean Plate is moving and under-thrusting from the south faster and this counter move results in the PRVI platform microplate having a (relative) west-southwest movement velocity (relative to the Caribbean Plate) of about only 2.5 mm per year.\(^22\)

To the south, beneath the Caribbean Sea, lies the Muertos Trough, where oblique under-thrusting of the Caribbean Plate occurs. The Northeastern Geologic Platform Bank of the Greater Antilles Arc boundary has active tectonics, resulting in high earthquake and seismic hazard activity. “According to Jansma et al. (2000), the buckling and folding of the plate boundary region is apparently accommodated largely by this offshore trenches and seismic (earthquake) activity takes place mostly within them, not within the PRVI block itself. This is good news.”\(^23\) The Seismic event density is centered offshore, north of the USVI and BVI in the Puerto Rico Trench area. It is relatively tame around Culebra, with concentrations also found offshore, southwest of Puerto Rico, including part of the Mona Channel and to the western half of the north shore, offshore from the towns of Arecibo, Isabela (lower) and Aguadilla Puerto Rico. The USVI island arc is also subject to severe periodic earthquakes with possible tsunami waves and annual hurricane events and extended annual cycles of limited rainfall. The last major earthquake event was recorded offshore the USVI in 1867, resulting in a tsunami on St. Croix that supposedly produced waves ranging in height from 9 to 12 meters. Major hurricane events occur frequently but generally not in all the islands of the Puerto Rico Platform at once.

This is the neighborhood, geographic setting and geology of our area of focus and study: Culebra, Puerto Rico with its neighboring Spanish Virgins, U.S. Virgins and British Virgin Islands. In addition to being located in a hot and humid zone 18 degrees north of the equator it is part of the annual hurricane belt.

**Topography of Culebra:**

Culebra dominant topographic features are its coastal cliffs, some of the most beautiful clean water beaches, a hilly interior and a large navigable inner inlet that divides it into a north side and south side and, several mayor bay areas . Its coastlines are of irregular contours and rugged with rock and sand outcrops, lagoons, coastal wetlands and mangrove areas and significant hilly contours and very little flatland. Its highest hills are Monte Resaca with an elevation of 650 feet (198 m) and Cerro Balcón with 541 feet (134 m) on the north side of the island. The central hill of the VMT parcel is the highest hill on the southern side of the island, in the Playa Sardinas II Ward, with an elevation of 350 feet (107 m).

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\(^{22}\) Lazell,2005, Ibid. p. 106

\(^{23}\) Ibid.
The island is volcanic in origin. Its surrounding cays, particularly the three larger ones, Culebrita, Cayo Luis Peña and Cayo Norte, exhibit similar topographic features. Around ninety percent (90%) of its land mass hilly with steep contours. The dominant topographic features that start in Punta Molinos in the northwest point of Culebra are the two higher hill ranges that split around the airport and extend through the Ensenada Honda inlet. The northern hill range trends from the west to the east towards Culebrita. The southern hill range trends in a southeaster direction past the town of Dewey towards Punta Soldado. It has sandy beaches including its largest Flamenco beach. Its irregular coastline is contoured and rugged with shallow shorelines with rock and sand outcrops that rapidly rise as coastal cliffs. It has some seasonal lagoons, coastal wetlands, and mangrove areas and very little flatland. It has no rivers draining sediment which, together with its inlets, coves, and bays, allow it to enjoy clear water beaches.

**Meteorology and Climatology:**

(Expanded from VMT’s Final EIS (DIA-F, by its Spanish acronym)

**Winds and Storm Events:**

The island of Culebra is subject to three wind patterns: (1) the prevailing Caribbean trade winds that blow at an average speed of 8 knots from the east-northeast from November through January, and from the east the rest of the year, (2) the sea breeze that blows from the prevailing northeast, east and southeasterly directions in a prevailing westerly direction during most of the year, except during winter when weather events from North America bring winds that blow from the northwest in a southeasterly direction, and (3) the land breeze that generally blows from the Caribbean Sea from the south or the southeast side of the island, but is also known to blow from the equator to the south during the warmer, late summer months. Hurricane events produce exceptional wind patterns that, due to the dynamics of their circular counterclockwise wind pattern, blow initially in a northwest direction and, as the hurricane eye approaches and passes, turn southeast. This counterclockwise circular wind movement of varying strengths, speed, intensity, proximity, and storm movement direction, cause substantial species damage, dispersion and recovery dynamics.

The Hurricane season extends annually from June to October with most storms occurring July to September. High energy storms cause significant damage to the property and infrastructure of Culebra. The storms originate off the western coast of Africa and generally move west or northwest direction tracking to the south, to the north or infrequently through Puerto Rico. Severe hurricane associated with el Niño cyclical weather influences from the Pacific ocean, occur every 10 to 20 years. The vegetation on the hillside also suffer damage from the strong winds and the coastal areas and beaches and sand bars suffer from the strong winds, higher sea levels from storm surge, wave setup and storm wash. The beaches suffer flattening by reason of erosion and damage to the upper beach deposition of the lower beach away from the beach face. The trajectory also affects which side suffers more damage. However studies conducted following the passage of Hurricane Hugo that struck in September 1989 with its 140 mile per hour sustained winds indicate that the immediate post storm damage to beaches, sand
deposits and corals is transitory and the beaches and corals recover. The studies conclude the fact of the recovery but the assertion that high energy storms may be needed to maintain the health of the delicate marine ecologies in the coastal areas.\textsuperscript{24} The vegetation was back on track and substantially recovered within two years except for the trees that were termite infested that fell or were uprooted completely.

The 1989 Hurricane Hugo storm that tracked northwest between St. Thomas and the east cost of Puerto Rico caused extensive damage destroying over 80\% of wooden structures and homes in Culebra. The storm did considerable damage to hillside tree and bush cover. Approximately 100 of the 300 vessels that took refuge in the “hurricane proof” protected Ensenada Inlet, due to the unprecendented high winds, were destroyed littering the shoreline. The storm and waves lifted and transported a large VI ferry vessels on to the hills on the west side of Fulladosa Bay, some 70 feet above sea level. The wind rose available in the former Roosevelt Road Naval Station record an all-time high wind gust of 104 knots.

**Prevalent Winds:**

According to the wind rose available in the former Roosevelt Road Naval Base Airport and the St. Thomas Airport, the nearest official data published by the U.S. Weather Bureau, the wind in the proposed development site of VMT blows predominantly from the east around 40\% of the time and from the east-northeast 20\% of the time. These two wind vectors represent the predominant wind direction 60\% of the time. Windy days can produce wind bursts of up to 32 knots. Wind events from the South and South-Southeast Caribbean Equatorial area cause higher temperature conditions and the northeasterly weather events from North America area cause lower temperature conditions.

The trade winds generally blow from the east and northeast during the winter and from the southeast during the summer and in the evenings all year. The trade winds tend to refresh and cool the island’s surface both during daylight and at night. The sea breeze and the land breeze generally blow in opposite directions. The counter movement from the southwest and the easterly counter flow causes inductive flows. Sea breezes are produced during the day due to the faster heating of the earth’s surface on the island than on the surface of the cooler seas, which causes the cooler sea breezes’ inductive flows to rise as they hit the warmer land masses. During the evening, as the land cools, the circulation pattern is inverted. Limited precipitation ensues in Culebra from these daily reversing inductive flows due to the lower elevation of its hills. The low hills allow the moisture-loaded clouds to move faster over the island’s low hills without enjoying sufficient height or time to cool and condense the carried humidity thus producing minor or no rainfall accumulation.

The seasonal wind patterns have a significant impact on the cycle of vegetation establishment since wind currents and cyclonic events, major habitation transporters of seeds and floating material, have

\textsuperscript{24} Swab, Dr. Williams ,High Energy Storms Shape Puerto Rico Fact Sheet, USGS Coastal & Marine Ecology Program, http://pubs.usgs.gov/fs/high-energy-storms/index.html
pre-established seasonal patterns that predetermine from what vector and floristic habitat a seasonal seed may be carried from and be deposited on an island such as Culebra.

**Temperature:**

Culebra enjoys a year round tropical marine climate with gentle breezes. Temperatures in the main island of Puerto Rico generally become cooler with the elevation as we travel up to the central mountain range with consequent lower temperature variances. In Culebra, the hills don’t enjoy such microclimate differences due to their low heights. The Culebra hilltops will generally feel cooler due mainly to stronger breeze patterns and not real temperature differentials. During the winter season, the average temperature is 74 degrees Fahrenheit with November through April being the cooler months. During the summer season, from June to September, temperatures average 90 degrees Fahrenheit. Relative humidity averages 67% to 70% during the year but can fluctuate to and remain above 80% during the wet seasons or during or after significant rain events. The more humid months are August to January.

**Historical Precipitation or Rainfall:**

There is general consensus that the late Pleistocene period which, Wikipedia defines as “the geological epoch which lasted from about 2,588,000 to 11,700 years ago, spanning the world's recent period of repeated glaciations “25 was much dryer and as much as 8°C cooler than today”26.” Relying on data from Curtis et al.200127 Lazell summarizes the last 8,000 years of precipitation as follow:

“Precipitation increased dramatically to a peak about 8,000 ybp [years before present], when sea levels was about 20 m. below its current level. There followed a dry spell, with precipitation falling off to today’s levels for about 800 years, then increasing to set the highest [during] Holocene, Wikipedia defines Holocene as “the geological epoch which began at the end of the Pleistocene (around 12,000 to 11,500C years ago) and continues to the present.”28, record of about 7,200 ybp (ca. 8,200 radiocarbons ybp). There was another drop to today’s precipitations levels at about 6,000 ybp (ca. 7,500

25 http://en.wikipedia.org/wiki/Pleistocene

26 Lazell,2005, Ibid. p. 108


radicarbons \textbf{ybp}). Then rainfall increased and continued to be high, right through the hypsithermal\textsuperscript{29} maximum, 6,000-4,000 years ago. The dramatic raise in sea level that brought the ocean up very close to today’s levels, ca. 4,000 \textbf{ybp}, was not complemented by changes in precipitation: Conditions remained much wetter than they are now. About 1,680 \textbf{ybp}, a 500-year spell of rainfall (similar to ours today), a relative draught, began. Following the 500 year draught, rainfall increased sharply after 1,200 \textbf{ybp} and peaked in a brief pluvial-period centered about 1,000 \textbf{ybp} with conditions as wet as they were during the long Holocene span of 6,800 to1,680 \textbf{ybp} – and much wetter than now. Since that time climate has died down to what we live with today.”\textsuperscript{30}

\textbf{Precipitation and Rainfall:}

Precipitation on the island of \textbf{Culebra} is mostly of \textit{orographic nature}. When masses of air in sea breezes containing moisture pushed by \textbf{Trade Winds} are swept from the ocean onto land up the side of a higher hills, adiabatic cooling results and, ultimately, condensation and precipitation of short duration follows. The higher hilltop range in the north side of the island, by visual appreciation of cloud cover and precipitation events, seems to enjoy more rainfall during the year than the lower hills of \textbf{Playa Sardinas II} ward and \textbf{Punta Soldado}.

I have observed over the years that moisture clouds arrive to \textbf{Culebra} predominantly from the neighboring \textbf{St Thomas} in the northeast and during stronger easterly fronts or hurricane events from both the \textbf{USVI} and \textbf{BVI}. The masses of air in sea breezes containing moisture over the warmer ocean pushed by \textbf{Caribbean trade winds} are first swept from the ocean onto land on the neighboring higher elevations of \textbf{St Thomas} where they produce rain events. This generates moisture laden clouds that are pushed again by the same northeasterly \textbf{trade winds} and continue their travel movement south westerly over \textbf{Culebra}. Its highest northern hills are \textbf{Monte Resaca} with an elevation of 650 feet (198 m) and \textbf{Cerro Balcón} with 541 feet (134 m) are on the trade wind receiving side of the island. The higher elevation of these northern hills of \textbf{Culebra} create a natural cooler condition that allows them to receive slightly more rain than the hills in lower elevations of the southwestern side. This pattern changes during the two rainy seasons, the first in May and next in September to November, many rainfall events reach the \textbf{Punta Soldado} side and southwestern shores of the island accumulating some rain and moisture. Many rain events in the \textbf{Punta Soldado} side and southwestern shores of the island are driven by southeasterly blowing trade winds.

\textsuperscript{29} A climatic phase in the early to middle part of the Holocene (q.v.)-lasting several thousand years-when conditions were appreciably warmer than today, is called \textit{hypsithermal}. http://www.springerreference.com/docs/html/chapterdbid/4549.html

\textsuperscript{30} Lazell,2005, Ibid. p. 108-09
There are two additional mechanisms responsible for rainfall in the Northeastern Caribbean: the (2) tropical wave currents coming from the east and the cooler (3) cold fronts (or “troughs”) coming generally from the northeast from the North Atlantic area of the North American Continent. Caribbean trades winds are refreshing but the cold fronts (or “troughs”) from the North Atlantic area generate more winds and cooler temperatures in Culebra and its surrounding waters. The cold fronts events bring a seasonal northwesterly wind pattern that travels in southeasterly direction over the island pushing the moisture laden clouds from the Puerto Rico’s mainland and St. Thomas away from Culebra to the Cuenca de Vieques channel south of Culebra. The cool air and ocean wave action that accompanies the front, cool both the island’s ocean water and land. This annual period of cooler climate and coastal water temperature coincides with Culebra’s dry season from January to April.

It appears that a phenomenon similar to the one that occurs during the longer El Niño and Humbolt Current weather cycles in the Galapagos Islands in the Pacific Ocean is repeated in Culebra with an annual seasonality. In Galapagos the prevailing climate effect of the cool Humboldt Current causes the shores of the southern islands to be bathed in cool waters, chilling the air and creating unusually cold conditions for equatorial islands. During this period, rain is scarce on the coastal regions. Only plants that can survive long periods of time without water can establish and develop in these climatic conditions. In Galapagos every seven years the pattern is reversed, when the cooler Humboldt Current is interrupted by the El Niño climate phenomenon, which drives warm waters that are normally sent westward by wind and the Earth’s rotation, toward the shores of South America and the Galapagos Islands. The El Niño inducted warm seas bring very heavy rainfall to the Galapagos. In Culebra the rain pattern impact of the cooler waters and cold fronts (or “troughs”) from the North Atlantic area appears to occur annually. The El Niño phenomenon changes wind and temperature patterns that warm the waters of the Caribbean Sea and the South Atlantic Ocean around the Equator with consequent changes in weather and climate patterns in the Caribbean Sea area and the southern Atlantic Ocean to the north. The El Niño inducted warmer climate and ocean waters also change the intensity, direction and frequency of annual Hurricane Events from July to October in the West Indies and the Gulf of Mexico.

Culebra’s rainy season extends from September to November. Rainfall also usually occurs during the month of May turning dryer during the summer months. This dryer summer rainfall pattern is disrupted, during the annual hurricane or tropical storm season that lasts from July to October. During the annual storm season rain events depend depend on the development, frequency, course, intensity and speed and direction of travel of the storms.

Culebra, however, is considered to have a dry tropical island climate due to its extended dry seasons and low total annual accumulated rainfall. The mean annual precipitation in Culebra averages 842
mm (84.2 cm) or 33.55 inches of rain annually.\textsuperscript{31} In 1994, the \textit{USFWS’ Recovery Plan} estimated mean annual precipitation was 975 millimeters (or 38.38 inches).\textsuperscript{32} However, rainfall in \textit{Culebra} can range from a low of 16 inches recorded in 1967 to a high of 59 inches recorded in 1942.\textsuperscript{33} The greatest accumulation of rainfall in a single storm event was 27 inches recorded in May of 1979.\textsuperscript{34}

A 2009 publication by Dr. Jose A Colón, who served as Director of the San Juan Office of the U.S. Weather Service for 23 years, provides a higher annual rainfall estimate. The publication indicates that “the data for a period of 19 years of the island of \textit{Culebra} – located some twenty five miles from \textit{Fajardo} – indicates an annual rainfall of 41.5 inches or 1,054.1 mm. The rainy season extends from May to November with less rain in June and July and a dry season from January to April.”\textsuperscript{35} (Translated from the original in Spanish) During 2013 we did an informal measure at \textit{VMT} of some 39.5 inches.

\textbf{The Geology of Culebra:}

\textbf{Historic Soil Formations}

\textit{Culebra} is the smallest and most arid of the three larger outlying islands of \textit{Puerto Rico}; \textit{Vieques} and \textit{Culebra} on the eastern shore side and \textit{Isla de Mona} on the western shore side of mainland \textit{Puerto Rico}. \textit{Culebra} and its adjacent islands and cays are all underlain by volcanic and intrusive rocks of the \textit{Upper Cretaceous} period, primarily \textit{andesite lava}.\textsuperscript{36} The lava is overlain by \textit{andesite tuffs} with \textit{diorite porphyry} intrusions in the north-central part of \textit{Culebra} and \textit{Cayo Luis Peña}. Due to compaction and filling of pores with quartz and calcite, this volcanic rock no longer exhibit porosity. In some areas such

\begin{quote}

\textsuperscript{32} 1 inch = 24.5 mm

\textsuperscript{33} Ordnance and Explosive Waste Search Repot [OEW], Feb, 1995, \textit{USACE Defense Environmental Restoration Program}, Project No. I02PR006802, p. 8

\textsuperscript{34} Ibid

\textsuperscript{35} Colon, José A. (2009). \textit{Climatología de Puerto Rico}. La Editorial, Universidad de Puerto Rico: San Juan, p. 123 and Figure 43.

\textsuperscript{36} \textit{Andesite} is an \textit{extrusive} igneous, volcanic \textit{rock} of \textit{intermediate} composition, with \textit{aphanitic} to \textit{porphyritic} texture. In a general sense, it is the intermediate type between \textit{basalt} and \textit{dacite}, and ranges from 57 to 63% \textit{silicon dioxide} ($\text{SiO}_2$) as illustrated in \textit{TAS diagrams}. The \textit{mineral} assemblage is typically dominated by \textit{plagioclase} plus \textit{pyroxene} and/or \textit{hornblende}. \textit{Magnetite}, \textit{zircon}, \textit{apatite}, \textit{ilmenite}, \textit{biotite}, and \textit{garnet} are common accessory minerals.\textsuperscript{37} \textit{Alkali feldspar} may be present in minor amounts. The \textit{quartz-feldspar} abundances in andesite and other volcanic rocks are illustrated in \textit{QAPF diagrams}. http://en.wikipedia.org/wiki/Andesite
\end{quote}
as hilltops, drainage basins and valleys, the intrusive rocks [volcanic flow sediment] have weathered to form rounded boulders.

The terrain where the VMT proposed action is contemplated is located in a geologic formation identified as TKa (“andesite dikes”) as described in the geologic maps of Puerto Rico, prepared by the U.S. Geological Survey (USGS).\(^\text{37}\)

TKa consists of a Karaisali geologic formation belonging to the oscine period, such as paleozoic-cene cretacic rocks like andesite, toba, brequia with lower content of limestone rocks.

The Karaisali geologic formation is mainly composed of reefal carbonates and dolomitic limestone at the investigated area.\(^\text{38}\) It is generally white to pale grey, medium to thick bedded and it contains

\(^{37}\) See Final EIS, Appendix 5, Geologic Map.

coralline algae, echinoderms, bryozoa, corals, mollusca and foraminifera. The Karaisalı formation accumulated on the pre-Miocene topographical highs and in the adjacent areas. The accumulations formed reef and associated deposits. The unit has a lateral and vertical facieses relationship with Kaplankaya and Gildirli formations at the base, and Güvenç, Cingöz formations at the top. According to the related fossil descriptions, Karaisalı formation might have been deposited during Burdigalian-Langhian time space.

Present Soil Formations and Conditions in Culebra:

Due to its volcanic origin, small size, rugged steep terrain and moderately uniform climate, Culebra has a limited variety of soil type. Its total acreage consists of about 70% to 75% soils of the DescaLABrado series (DeE2) that predominated in the prevalent 20% to 40% slope contour areas. These areas are well-drained with rapid runoff and moderate or low permeability. These soils formed in moderately fine texture and fine textured residuum of volcanic rock.

The other soil type found all over the island is the Rock Soils series (Rs). It is easy identifiable in areas where rocks or rock formations crop out on top of the soil surface. The outcropping is cause by historic weathering due to the steep gradient and rapid rain drain. Many times up to 50 to 70 percent (50-70%) of the surface has exposed rocks and rock accumulations. Its total acreage of consists of around 10% to 15% of island surface. Loose single stones are also very common on the surface.

39 Ibid.
40 Ibid.
41 Ibid., Fig. 5,6.
42 The Burdigalian is, in the geologic timescale, an age or stage in the early Miocene. It spans the time between 20.43 ± 0.05 Ma and 15.97 ± 0.05 Ma (million years ago). Preceded by the Aquitanian, the Burdigalian was the first and longest warming period of the Miocene[1] and is succeeded by the Langhian
http://en.wikipedia.org/wiki/Burdigalian

43 Cavit Demirkol. (1989) above, p. 3

Throughout the island pocket areas of Jacana series JaC2 soils are also found. These soils are similar to Descalabrado series soils but more fertile and prone to run-off wash. These soils occupy foot slopes and low rolling hills in semi-arid areas. Its profile is similar to the Jacana series profile, but some of the surface layer of dark grayish-brown clay has been removed by erosion. These soils have high natural fertility and high shrink-swell potential. Rapid runoff and moderate permeability require good management and conservation practices to slow surface runoff. Soil coverage in Culebra is very shallow, it soil coverage is between 12 to 24 inches thick with a hard volcanic rock beneath.\(^{45}\)

In profile Descalabrado series soil starts with a dark reddish-brown surface layer, neutral clay loam about 5 inches in thickness. The next layer is reddish-brown, friable gravelly clay 7 inches thick. The underlying layer is yellowish-red firm gravelly loam. Volcanic rock is generally at a depth of 18 inches many times less. These soils have a moderate availability of water capacity, medium fertility, and a moderate shrink-swell potential. Runoff on these soils is moderate when dry to rapid. These soils are difficult to work and many have been dedicated to pasture for many years.\(^{46}\)


\(^{46}\) Soil Survey, Humacao Area of Eastern Puerto Rico, USDA, Soil Conservation Service, 1969, p.21
Predominant Soil Formations at Villa Mi Terruño:

The predominant soil formations at the VMT site, like most soils in Culebra, are classified into two (2) series: Descalabrado clay loam (DeE2) and Rock land (Rs) as defined by the Soil Survey of the Humacao area of Puerto Rico prepared by the U.S. Department of Agriculture’s Soil Conservation Service.

The detailed description of the two series follows:

**Descalabrado clay loam (DeE2):**

This DeE2 series of soils is found mainly on the northwest drainage basin behind the western lower saddle hill and on the eastern lower northern hillsides of VMT's lower hills on the northern side draining to the Ensenada Honda. This soil series is shallow and can be found to the depth of 1 foot to 1½ feet over the mother volcanic fractured rock base layers. This soil series is also found with greater topsoil depth in limited areas of the lower northern drainage basin that can accumulate natural historic soil runoff from higher elevations, such as the two small saddle areas on top of the northern lower hill and near the base of the northern central drainage basin before the municipal road.
DeE2 soil series North Lower Hills

This DeE2 soil series is not adequate for farming due to its shallow depth and steepness of the hill contours from 12% to 40 % that makes the terrain propitious to fast runoffs, that rapidly remove the water with consequent less accumulation and retention of precipitation and a tendency to cause erosion. Annual precipitation delivered with seasonality on these soil areas is around 35 inches.47

The unit capacity of DeE2 soils in VMT is VII-4. The unit capacity is divided in class, subclass and unit. The unit of capacity of VII describes those soils that have **very limited capacity or value to support farming**. The “s” subclass of unit capacity or VII, describes those soils that have severe limitations due to their **rocky nature, shallowness and for their limited capacity to retain water**. The unit category “4” of unit capacity iVII-4, describes the ground of this soil series as **steep or very steep**, with good drainage and of a moderate to fine texture.48


**Rock land (Rs)**

Rs soils in VMT are found in areas where rocks or rock formations may crop out on top of the soil by weathering on the surface many times covering up to 50 to 70 percent (50-70%) of the surface. Loose single stones are also very common on the surface. Very shallow soil material lies between the outcrops and stones. This Rock land (Rs) soil series is predominant in the VMT property with total acreage coverage of about 75% of the site. This Rock land (Rs) soil series starts in the western boundary of the site and along the cliffs and steeper hillsides of Playa Cascajo on the southern boundary of the site. It continues north over the southern hill, covers the entire Green Valley drainage area, runs over both the top sides of the higher central hill traveling north and then continues in a northeasterly direction to the middle northern side boundary of the central hill. Slopes are up to 40 to 60 percent (40-60%). The vegetation is mainly brush and small trees.

**Rock land (Rs) terrain coverage**

Rock land has little value for farming or production uses because of the steep slopes, erosion hazards and workability. Its use is restricted mainly to xerophitic vegetation flora and only provides a limited wildlife habitat in Culebra for the small wildlife fauna population.49

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Soil Evaluation Exploration Report of the Villa Mi Terruño Site:

A Soil Evaluation Exploration and Report was carried out in the Villa Mi Terruño site in February, 2015 by engineers and personnel of Suelos Inc.\(^5^0\) The primary purpose of the report was (1) to determine the nature of the underlying soils and stratification of the site, (2) obtain representative samples for visual and laboratory analysis, (3) use data to recommend site development and (4) determine the need and performance of cut and fill operations and geometry of slopes.

Fifteen (15) test holes were drilled to depths varying from 5 to 20 feet within the premises of the referenced site. The test holes were advanced using the Power Auger Method and rotator diamond bit rock coring. One (1) percolation test was performed on the southern portion of the site.

Surveyed SUBSOIL CONDITIONS:

The site survey and drilling samples confirmed the general information issued by the US Geological Survey that the native soil materials disclosed by the soil exploration belong to the Descalbrado clay loam DeE2 and Rock land (Rs) volcanic and volcaniclastic rocks described in the geologic maps. The survey also disclosed more specific soil condition and soil horizon information.

The subsoil conditions found consists of three (3) horizons: an upper very stiff soil horizon, a saprolitic (or extremely weathered rock) horizon, and the local weathered rock of Culebra. The description of the soil horizon findings follow.

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First Horizon (Very Stiff Soils)

This horizon consists of 1.5 to a maximum of 17.5 brown and grayish brown, very stiff, silty clay and/or clayey silt with abundant angular rock inclusions. SPT “N” values ranged from 15 to over 50 blows per foot, while the natural moisture content ranged from 4 to 22%. Although the horizon was found on boring 2 to a depth of 17.5 feet, the norm of the horizon thickness was from 3 to 5 feet.

This horizon is a residual in-situ soil horizon, product of the volcanic and volcaniclastic rocks, except for borings 1, 6, 7, 8 and 11 where it may be reworked material from small scale earthwork operations within the farm and/or colluvial material.

Second Horizon (Saprolite)

Below the first horizons and sometimes starting at ground surface, a mixture of varied colored weathered and angular rock fragments were found generally from 1.5 feet to a depth of 20 feet in borings 1,2,4,9, and 11. On the remaining borings the horizon is under laid by rock (the third horizon) or the borings were left at refusal before the 20 feet of depth.

SPT values were invariably 50 blows per several inches and sometimes no recovery at all, while natural moisture content ranged from 1 to 10 percent.

Third Horizon (Rock)

The third horizon was drilled through on borings 5, 6, 9, and 10. It consists of a gray colored, massive, highly fractured andesitic ground mass with plagioclase crystals.

Rock Quality Designations, or RQD (a measure of as rock’s soundness was 0 for all the rock cores sampled). This rock is abundant and visible throughout the farm on outcrops and along some of the existing access trails.

Percolation Tests

A percolation test was performed on the south side of the farm following government of Puerto Rico issued requirements. The percolation rate estimated was 30.83 minutes per inch.

Hydrology - Watersheds, Streams and Surface Waters:

Hydrology and Historical Water Supply:

Fresh water and potable water has always been a scarce resource in Culebra as there is no natural permanently flowing stream or reliable natural springs. The principal aquifer of Culebra is the fractured
volcanic rock with a probable water storage capacity of less than 1%.51 Historically residents had to collect rainwater for its potable and home and agricultural water during the seasonal rain events. A mayor challenge and survival risk in an island with a lengthy dry season that can extend between four to six months in the early and mis spring and summer months. During the wet season, more than 70% percent of annual precipitation occurs within five months when rainfall averages more than 100 millimeters (2.54 inches) per month and mayor rain event appear.

Creeks and streams in drainage basins are generally dry and only collect rainwater during rain events and storms. A number of generally manmade retention ponds exist throughout the island. Some are used for irrigation of gardens and limited agricultural use. Many of them dry out during the dry rain season. There a limited number of natural springs and seeps, about a dozen, that dry out and need to be recharged during the next rainy season.

Some wells had been used during the early years of habitation of depths of 10 to twenty feet in areas away from the saline coastal seepage, but these wells are also high in chlorine concentration and salinity making them not suitable for human consumption. Most of these water supply and catchment systems are no longer in use. Some home continue to operate with rain water wells. Public water supply distribution to some of the more isolated areas was slow in developing. VMT’s sustainable design calls for collection of rain water for showers, toilets and gardens. The Puerto Rico Water and Sewer Authority (“AAA”) historically operated 11 water wells in Culebra with 6 wells in the San Isidro ward until a new desalination plant was built and an undersea fresh water pipe was laid from Vieques to the south coast of Culebra. Before the construction of the Desalination Plant the Municipal wells field of 5 wells was the mayor source of water for public supply for, then, a smaller population.

An inventory of water wells was carried out from May to June 1991 by the USGS 52 and a Report was published in 1995. The report described 77 wells of which two are found in the VMT property. They were dug by the Fishbach family the prior owners of the property to provide water for cattle grazing. Of the 77 historical wells, by 1991 only two (2) were operating for household use and four (4) for agricultural use. Most are probably close today or use for garden or non-potable use.

**Present Water Supply:**

Today the water system has three sources of fresh water, i.e., rain water, AAA desalination plant and a potable water supply by pipeline from mainland Puerto Rico sources through undersea piping via Vieques.


52 Cherry, Gregory & Ramos, Juan, Water Wells on Isla de Culebra, PR, 1995, USGS Open-File Report 95-369
Most of Culebra used to get its potable, household and commercial and service use water originally from desalination plants first build by the US Navy and later by the public AAA in 1971 when consumption was 120,000 g/d. The capacity was increased in 1980 to 150,000 g/d and has been programmed for an additional increase to 200,000 in the AAA general 5 year Capital Improvements Plan. The population of Culebra in 1971 was 996 inhabitants and currently some 1,818 permanently inhabit the island as of the census of 2010. A larger tourism visiting population increase demand year round with seasonal peaks.

AAA supplies water from Puerto Rico through an underwater aqueduct. Installation of this system had a cost of over $7,400,000 dollars. The water distribution system is not island-wide and is limited to urbanized areas. The water comes from mainland Puerto Rico from the Rio Blanco Reservoir and the filtration plant of Naguabo near the east coast of the island fed from the El Yunque south drainage area. A undersea pipe transports 1.2 million gallons a day to Vieques of which 200,000 gallons are supplied and piped across Vieques and transported again by in a submarine 10 inch pipe some 19.8 kilomers (9 miles) to Playa Cascajo. Coming inland and passing through the south western Playa Cascajo border of VMT it goes by land to the main water tank of the AAA in Culebra. AAA has a desalination plant in the Fraile sector of Culebra with a capacity of 150,000 gallons with the expanded 200,000 desalination plant that is operated to supplement the water supply during seasonal tourist peak occupancy and demand periods in Culebra. AAA has a total storage capacity of 1.075 million gallons in five tanks.

**Villa Mi Terruño Watersheds:**

According to an evaluation of the site topography (based upon evaluation of the USGS 7.5 minute topographic map) the site has six distinct watersheds, each with its own natural drainage patterns.

According to the USGS’ Topographic Map of Culebra, VMT’s general topography is accidental with elevation contours ranging from approximately 5 meters MSL to 100 meters MSL. It consists of three hill ranges dominated by a central hill with 100 meters of elevation. The northern hill range is subdivided into a central hill range and a northern lower range of two hills. The two lower northern hill ranges are divided by a central drainage basin that drains into the Ensenada Honda Inlet bay. In the western midsection, between the higher central hill range and the northwestern half of the lower hill range saddle, a second smaller basin drains northwest towards Laguna Lobina. The second contour feature is the central hill range with a height near its center of 350 feet. The central hill range has on its west side a horseshoe-like western saddle wrapping hilltop that first turns southwest and next turns southeast in its south western end into the hilltop of the third lower southern hill. The eastern northern half portions of the central hill range also drain to the northeast into the Ensenada Honda Inlet bay.

The south side of the central hill range, the east side of its western saddle loop and the north side of the lower south hill all wrap around a green central drainage basin designated by VMT as “The Green Valley or Valle Verde” that drains into the Fulladosa Sound Inlet to the southeast. The western section of the southern saddle wraps and continues into the lower southern hill. The Valle Verde together with the cliff associations on the Lower South Hill facing south to Playa Cascajo and its hilltop connection
east to the Green Valley, the Green Valley and the north hillside of the Central Hill Range that drains form the core component of the South Ecological Corridor.

Lastly, the south hill range with a height near its center of 250 feet has two separate smaller watersheds, one on the eastern half draining southeast into “Playa Cascajo” and the “Sonda de Vieques” and the other on the western half drains into a small seasonal natural retention pond watershed area behind Dátiles Beach on the Caribbean Sea side to the west. This southwestern basin does not drain to the sea. The Leptocereus grantianus habitats are found in the south side of the upper south hill range near the center and in the southern coastal cliff association in two locations near the Playa Cascajo beachfront.

The VMT site fronts in approximately 443.2524 meters along the beach front of Cascajo Beach on its southern boundary fronting the Sonda de Vieques. The terrain elevation feature on this southern boundary is a steep cliff with height varying from twenty (20) to ten (10) meters above mean sea level on a sharp rise with inclines from 60 to up to 90% along the property’s approximately south boundary width of some 420.2524.2524 meters of said cliff extension or about 95 % of the frontage. A small frontage in the southwest boundary of approximately 10 meter has a lower elevation of around ten (10) to five (5) meters above mean sea level. Continuing east from the turn corner another small frontage of approximately 12 meter traveling east again along the boundary has a lower elevation of around five (5) to three (3) meters above mean sea level. The Playa Cascajo surface is composed of dead coral stone, some sea shells and rocks and boulders of varying sizes. Large boulders are present in some areas of the beach and the waterline is generally rocky along the sea shore beds and cliff boundary fronts, thus for its worn rocky and seashell composition the beach areas is known in Spanish as Playa Cascajo for these features.

The drainage basins and watersheds at the southern half of the site are a consequence of the site’s ridge, saddle and steep elevation contours. The areas immediately adjacent or within the drainage catchment areas that typically harbor the most dense and diversified ecosystems. These areas include the least stable soils of the site. The drainage basins are not permanent streams but rocky or rock soil
dry drainage systems that functions upon the occurrence of major rains. The flora and fauna ecosystem that inhabit these drainage systems enjoy the benefit of receiving more concentration and pocket retention of water during the intermittent rain events with some concentration and accumulation during smaller events. Most rainfall during the dry season is quickly absorbed by the dry land and vegetation and does not flow into the drainage basings or ocean. Sediment only drains predominantly on the northern side to the Ensenada Honda Inlet bay during the fall seasonal rainy season or during hurricane events in the summer.

Adapting the VMT Model Ecologically Sustainable Project to its Site:

Villa Mi Terruño is a Model Ecologically Sustainable Residential Tourism Project of advanced master planning proposed on a 104 cuerda\textsuperscript{53} land site in Culebra. It is located on three raising and falling hills at the center of the Playa Sardinas II Ward in the southeastern peninsula extension of the island between the Ensenada Honda Inlet to the north and the Playa Cascajo beach on the Vieques Sound of the Caribbean Sea to the south.

Culebra’s geographic and geological reality, or its place in the world, as described above, will only allow a certain universe of natural ecological-process rates to occur without continued artificial management efforts, such as irrigating crops growing in a desert\textsuperscript{54} or, in our case, having to water exotic nonnative flora in Culebra. External human intervention may be able to expand these natural ranges but cannot completely avoid the limitations of place without an artificial intervention and loss (e.g., water).\textsuperscript{54} The sustainable development proposed on the VMT site maintains and protects large, almost 70%, of undisturbed green areas and ecosystem processes by enhancing productivity of the more significant vegetation covered areas, through reforestation with native species, for example, thereby improving natural evapotranspiration rates and filtration of water and nutrients to the soil.

Summary Description of the Villa Mi Terruño Project:

“Villa Mi Terruño proposes to develop a mix use residential-tourism project. The project consists of two (2) tourism facilities of the lodge or parador type, with 32 rooms each when fully developed, a camp cabin facility to house youth occupants, with 5 cabins of three bedrooms each for a total of 15 camp rooms and 69 structures that when fully developed will provide 110 residential vacation homes and a 5,059 square feet facility to be used as an accessory and clearly incidental area for service and

\textsuperscript{53} One (1) cuerda = 0.971 acres

\textsuperscript{54} The Ecological Society of America’s Committee on Land Use, 5.
maintenance of the site and facilities of the project. It proposed a Green Continuous Ecological Corridor (CEC) which shall be protected in perpetuity by means of environmental easements.⁵⁵

The proposed development will be built on some 34 cuerdas of a 104.17 cuerdas land site on the Playa Sardinas II Ward of Punta Soldado, of which some 70 cuerdas will be set aside for conservation. During the process of discussing the proposed Master Plan for permitting with the different environmental agencies, the project was modified and reduced significantly and lessen its potential impact on the environment and natural wildlife. As a result, a general area of only 34 cuerdas, historically altered for agricultural grazing and housing uses, will be developed over a 15 to 20-year period. In fact, the net development residential footprint impact on this historically impacted land, dominated by grasslands and mostly exotic invasive species, is of only 8 cuerdas on Rock land soils, out of the 34 cuerdas dedicated to residential construction. The remainder of the site or the 70 cuerdas being set aside for conservation include a Continuous Green Ecological Corridor that shall be protected by means of restrictive covenants and land and perpetual easement transfers to VMT’s Mi Terruño Foundation (Fundación Mi Terruño), also referred to as the Ecological Foundation, in the form of perpetual conservation easements.

Density of Site Use and Placement of Homes and Tourism Facilities:

The conceptual Design Guidelines and pre-development and final Master Plan of Villa Mi Terruño harmonizes the density of site use by the placement of its vacation housing units into lateral clusters and in the site’s previously disturbed areas to limit its net impact and protect the site’s most ecologically significant habitats. The Master Plan equally sets its small-scale youth campsite, ecotourism lodge, and tourism condo family lodge facilities on the flatter top contours of the hills within the previously disturbed cattle grazing lands. The units and facilities are carefully placed in the environment to maximize the aesthetic contours and make the most of the beautiful vistas of the sky, island and its inlet, surrounding sea and neighboring islands for the enjoyment of residents, guests, and visitors. The placement of homes will particularly consider terrain contours and natural elements found at and around the homes and the facilities’ sites to be able to integrate them as seamlessly as possible into the visual landscape.

The residential tourism homes, the small ecotourism lodges, as well as the boys and girls camp, focusing on a youth environmental and nature conservation teaching program, creates a protected development bridge between the nearby urban town of Dewey and its permanent residential and service areas. It provides a less dense development alternative that can help manage, in a sustainable and environmentally sensitive manner, the urban, resort residential and temporal tourism demand and growth pressures on the southeastern natural development belt of Culebra and its urban center.

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⁵⁵ Approving Resolution of the Puerto Rico Planning Board Master Plan Application 2007-77-0047-JPU, p. 11, December, 2012
The Villa Mi Terruño site sits in the middle of the island’s *southeastern urban development expansion belt* from the town of Dewey. The residential tourism homes, the small ecotourism lodges or “Paradores”, as well as the boys and girls camp, with a focus on a youth environmental and nature conservation teaching program, creates a protected development bridge between the proximate urban town of Dewey and its permanent residential and service areas. It provides a less dense and more environmentally sensitive development alternative that can help manage, in a sustainable and environmentally sensitive manner, the urban and tourism temporal demand and growth pressures of the southeastern natural development belt of Culebra and its urban center.

The regeneration of native established trees and denser vegetation in these disturbed grassland areas has not been significant due to the limited and seasonal rain the site receives, the rock land characteristic of the soil associations and the shallow soils prevalent in Culebra. The zones of life and climatic conditions that prevail in the VMT habitats of these historically disturbed areas extends the period for a new plant to establish itself and start recapturing the life zone. The competition from introduced aggressive species like *Mesquite* that was brought in seeds that remained in the dung of imported Texas cattle, makes it more difficult and extends the period for a local plant to reestablish itself and start recapturing the life zone.
Coherent Sustainable Design Guidelines and Development

Slow Managed Process to Reestablish and Restore the Historical Subtropical Dry Forest Vegetation and Trees after a Century of Disturbance and Replacement with Grazing Pasture Associations

Protection of trees and vegetation and scenic stone formations and terrain features in historical less disturbed Slopes and Valleys.

Ecologic Conservation of Continuous Green Corridors Set Aside to Protect Endangered Species and Reestablish Historic Dry Subtropical Forest

Restrictive Covenants and Perpetual Easements Established to Protect Ecological Corridors and Significant Flora & Fauna

Accordingly, these historically disturbed areas are more suitable for locating new development because the placement of facilities into these areas reduces the degradation of established vegetated areas and the development impact has no significant incremental effect since they were previously disturbed and have not regenerated. The sustainable development plan integrates and protects the natural environment and biota such as the green valleys, steep coastal cliffs, significant vegetation, mature trees and cacti populations, fauna habitats. Rock formation and natural landscape contours are also protected as a key visual and scenic element in the placement of the units and facilities. The VMT Master Plan also protects endangered vegetation and restores the autochthonous flora and fauna species that occupy its dry subtropical habitats.

The conceptual pre-development Master Plan of Villa Mi Terruño harmonizes the density of site use by the placement of its vacation housing units into lateral clusters and in the site’s previously disturbed areas to limit its impact on the habitat. The Master Plan equally sets its small scale youth campsite, ecotourism lodge and tourism condo family lodge facilities on the flatter top contours of the hills within the previously disturbed lands. The units and facilities are placed in its environment in a sensitive manner to its aesthetic contour and beautiful vistas of the sky, island and its inlet and surrounding sea. The placement of the homes considers terrain contours, green corridors and natural elements found at and around the home and facilities sites.
Phased Development of the VMT Project

The gradual long term development of this type of sustainable and environmentally sensitive vacation housing and eco-tourism development will provide much needed input to the future economic sustainable development of Puerto Rico and Culebra. It will cause a significant impact, as a sustainable third economic sector, that creates indirect and direct job opportunities both during and after its construction.

The gradual market absorption provides an orderly and sustainable market supply and demand economic inductors that will both build, support and supply tourism development for the benefit of the local and insular economy. At the same time, it creates and sustains new opportunities for local orderly participation and economic growth to meet the gradual increase in demand for vacation housing and lodging, transportation, recreational services, food and beverage requirements, restaurant and entertainment. It also stimulates and provides job opportunities to supply the services for the gradual construction and development as well as the resulting long term operation of the tourism facilities and the operation, supply, cleaning and equipment, electrical, mechanical and infrastructure maintenance and replacement service requirements of the vacation homes, service facilities, its vehicles, public services and gardens.
**Description of the Villa Mi Terruño Ecological and Conservation Corridors:**

**VMT Ecological Corridor concept incorporated:**

The proposed *comprehensive design guidelines* of the VMT Master Plan provide for the setting aside and title transfer from the developer to Fundación Mi Terruño Inc. ("FMT"), a scientific and educational non-profit organization also referred as the “Ecological Foundation”, of a large track of land of approximately 40 cuerdas of the 70 cuerdas that are being protected. The set aside land area provides a contiguous green corridor of subtropical dry forest to be reserved for educational, scientific and conservation uses. The original master plan was revised and the VMT Ecological Corridor concept *incorporated*, after site visits and formal recommendations of the USFWS and DNER, to reduce the original conceptual size and reconfigure the facilities of the project. This was achieved by relocating and eliminating several of the proposed housing sites from the central hill areas and transferring the home sites into side clusters toward the outside east and margins of the proposed project site. This allowed for a bigger VMT Ecological Corridor.

The revision also included grouping some proposed sites closer together into clusters to minimize possible impacts upon the remaining portions of undisturbed natural habitat areas, to allow or enhance the area and continuity of the proposed green corridor and to relocate and transfer the proposed residential use to the previously disturbed cattle grazing areas.

**VMT proposed long term recreational development will**, in effect, only occupy and be gradually developed in 33.7 cuerdas of land over a period of some 15 to 20 years of which only 8 cuerdas will suffer permanent impact with the homesites at full completion. The remaining 70 cuerdas will be set-aside and protected in perpetuity by title transfers and conservation easements.
The **VMT South Ecological Corridor** and **North Continuous Green Corridor** extend from the Playa Cascajo beachfront on the southern side of the property of the Playa Sardinas II peninsula to the northern lower hill sides fronting on the Ensenada Honda Inlet area. The **Master Plan** proposed that approximately **70 cuerdas** be conserved and not developed. This significant set-aside and protection for future generations of the flora and fauna ecosystems in the most sensitive environmental biota areas of the **VMT** proposed site is a core action of the plan most uncommon in development circles.

The voluntary set aside proposed by the **VMT comprehensive design guidelines** was adopted by the Planning Board of Puerto Rico when it approved and authorized the **VMT “Consulta de Ubicación”** or Master Plan in its Resolution of December 2010 and again in its more detailed approval in December 2012.

The **VMT Ecological Corridor** will be expanded and enhanced with an additional **19.5 cuerdas** from adjoining proposed home sites that are abutting and contiguous to the **VMT** corridor to increase the aggregate protected terrain by means of **irrevocable conservation easements in perpetuity**. The Master Plan thus provides for some **60.1 cuerdas** to be set-aside by deeded transfers or easements for the
benefit of FMT, as title holder or dominant title holder of a perpetual conservation easement to form part of a contiguous green corridor, or 57.7% of the total proposed master planned recreational community. The titled and easement transferred rights shall be held by the FMT for the enjoyment of present and future generations. Additional fractured or noncontiguous green set aside areas along the dry drainage basins and the green individual land patches of some additional 10 cuerdas will also be protected for a total of 70 cuerdas. FMT will establish within the VMT Ecological Corridors, the first Botanical Garden in Culebra, with nature trail, reforested gardens and propagation and reforestation greenhouses. These transfers will allow for at least 70% of the site to be either perpetually preserved as a protected area, as a reforested and restored gardens of endemic species, as a dedicated research and reforestation green planting areas or as gardens. The entire protected area will be either administered or supervised under FMT’s title and easement rights and under the community development covenants to be enforced by the Homeowner Association and by FMT title holder or as dominant tenant, including the VMT Ecological Corridor and the so-called Green Valley Area in the South Ecological Corridor between the central hill and lower south hill that a pristine developed dry tropical forest area. As of the first quarter of 2016, a small set aside of some 8 cuerdas in the beachfront area of Playa Cascajo in the South Ecological Corridor is under discussion with the DNRA in connection with the Habitat Characterisation endorsement that would be entitled to DNRA, as dominant tenant title and FMT retaing the serviant tenant with the operation and management of the perpetual easement responsabilities.

The aggregate conservation set-aside area and the VMT Ecological Corridors to be known as the South Ecological Corridor and North Continuous Green Corridor is one of FMT Foundation’s nuclear goals and of VMT’s proposed sustainable and recreational tourism model community. The fulfillment of this goal of creating a relative large dedicated conservation set-aside area will establish a new model standard of development in communion with nature that uniquely sets aside some 70% of the proposed development’s master planned area for present and future generations. These proposed conservation
parameters are exceptional conservation measures that exceed the standards of LEED’s Platinum development projects for these types of measures and will provide palpable model guidelines and set standards of sustainable or “green” development for Culebra and Puerto Rico.

The conservation easements will be imposed at the time of transfer on the titled land sites of the 39 future single-family residential tourism homes as the same may be developed during the next 15 or possibly 20 years. These conservation easements will be implemented by means of development covenants, easements and construction restrictions which shall be incorporated into the individual rights and title transfer deeds over the development cycle of the property. A total of nineteen and one half (19.5) cuerdas will be reserved in perpetuity and set aside on the basis of one-half (1/2) cuerda of each of the individual one (1) cuerda single family home-site lots that adjoin the Ecological Reserved Corridors. The owners of the specific lot, under supervision and in coordination with FMT can follow the conservation and reforestation guidelines of the easements and covenants and reforest and enhance the half-acre protected areas with native xerophytic vegetation and trees. The restrictive covenants will additionally limit the area for the planting of exotic around the homeowners other half cuerda home sites to allow for better management and conservation of water consumption. This allows for a model contiguous protected area and plenty of undisturbed transition land to pursue the conservation, educational, research and reforestation goals of FMT.

The VMT Subtropical Model Dry Forest:

To expand the core conservation goals and enhance the dry forest flora of the VMT Ecological Corridor, Fundación Mi Terruño (FMT) and Culebra Resorts Associates II (VMT) have worked together and spent the past decade protecting the significant vegetation in the approximate contiguous 60 cuerdas of the corridor. To continue expanding these efforts, in August, 2012 with the consent of VMT, FMT entered into collaborative agreement with the US Fish and Wildlife Service (USFWS) under the agency’s Partner’s Program. The agreement calls for the construction of a greenhouse, the establishment of two new communities of the endangered Leptocereus grantianus cactus in the VMT South Ecological Corridor and the reforestation planting of some 1,260 native dry forest trees.

This joint initiative, that is not frequently similarly seen in development projects, provides for a grant of $20,000 from the USFWS’s Partner’s Program and the matching of a similar $20,000 amount by FMT that is being provided and funded by VMT.

The agreement allows for the construction of a modern greenhouse on the VMT site and the planting and establishing for up to two years in the nursery of sixty plants of the endangered Leptocereus grantianus cactus that were gathered by the USFWS biologists from the three populations of the cactus that are present and protected in the VMT site. Once these plants have established themselves and matured in the nursery, the agreement calls for the planting and establishment of two new populations of the endangered Leptocereus grantianus cactus in the core 38 protected cuerdas or near the Botanical Garden of the VMT Ecological Corridor. The Leptocereus grantianus planting was carried out during the last Quarter of 2015 and first quarter of 2016.
The agreement also calls for maturing 1,260 dry tropical forest trees to be provided by the USFWS in the greenhouse nursery and the planting of 315 trees per annum climatic conditions permitting. These trees were collected by the USFWS in their greenhouse in Boquerón, Puerto Rico and transported to Culebra to be cared and matured in the new VMT Greenhouse for planting within the VMT Ecological Corridor.

Some of the species transferred for the Reforestation Program planting included, among others, Bucida buceras L., Ucar - Oxford Bucida, Bursera simuroba (L.) Sarg., Almancigo - Turpentine, Bourreria succulenta Jacq., Palo de vaca, Roble de guayo - Pigionberry, Coccoloba microstachya Willd. Uberillo - Pockhout, Eugenia ligustrina (Sw.) DC. Granadillo, Hoja menuda, Palo de mileta/ de murta – Birch berry, Privet-stopper, Erythroxylum aerolatum L., Indio, Cocaina falsa - Coca shrub, Ficus citrifolia Milller, Jaguey blanco, macho - Wild Banyan Tree, Boislaglu, Coccoloba krugii Lindau, - Wild Grape, Whitewood, and Guaiaum officinale L.. Guayacan - Lignun vitea , among others. In addition VMT and FMT personnel have planted in the Greenhouse other species including, among others, Ficus benjamina L., Laurel Benjamin - Weeping Fig, Chinese Bantam, cacti species of Culebra and the Coccothrinax alta (O.F.Cook) Becc., Palm Abanico - Teyer Palm that grows on the hills of Culebra. The agreement calls, weather permitting, for planting these trees in four annual cycles of 315 trees each during the rainy fall and early winter season of Culebra’s climate cycle. The unusually dry extended rain season during the past two years and the current quarter (2014-16) has delayed full implementation since watering of plants is require during the arly months after planting to improve their establishment survival.
During the first seven months of 2015 some 25 different species of dry subtropical forest plants and flowering trees have been propagated by VMT and FMT personnel in the greenhouse from seeds and cuttings producing close to some 400 additional plants to enhance the conservation areas.

The reforestation and planting will assist in further developing the VMT Subtropical Model Dry Forest in the VMT Continuous Ecological Corridors as authentic dry sub tropical forest with indigenous vegetation.

The first work and review visit was carried out during the week of July 7, 2013 to examine the completion of the greenhouse, the condition of the existing populations of *Leptocereus grantianus* being protected in the VMT Ecological Corridor and to collect stems and plant material to plant 60 new plants in each of the USFWS greenhouse and VMT greenhouse. The 1,260 native dry forest trees were picked up in Boquerón in February 25, 2014 and transported and delivered in the VMT greenhouse on February 27, 2014. The dry forest trees are being stabilized at the greenhouse so they can establish themselves and mature in the nursery. The first cycles of 315 trees will be planted during the fall and early winter humid season of Culebra’s climate cycle starting in 2014-16. The original target date for
completing the project was 2016 but may have to be extended due unexpected dry climatic phenomena that has prevailed during the first seven months of 2015 that does not allow any planting.

New Greenhouse Building

Loading Trees & Plants in Boquerón, P. R. Vivero

The initiative to help continue establishing a species in danger of extinction, such as the reproduction and painting of Leptocereus grantianus cactus, the planting from seed for reforestation of local autoctonous plants and trees and the reforestation and planting of some 1,300 species to assist the further development the VMT Subtropical Model Dry Forest in Culebra are significant core projects. The regeneration of an authentic dry subtropical forest with indigenous vegetation is an effort that requires a solid commitment of all the parties involved. Both Fundación Mi Terruño and Culebra Resorts Associates II have together spent the past decade protecting the significant vegetation in the approximate contiguous 60 cuerdas of the vegetation of the VMT Ecological Corridors in Culebra. Habitat reforestation and enrichment of species being currently implemented under the Partners Program with the USFWA and DNER can additionally help prevent degradation and enhance development of the flora communities. It will also allow for an undisturbed forested area where fauna species can also enhance and develop their communities.

Culebra’s Ecosystems, Ecological Associations and Sub-ecosystems:

Culebra enjoys a warm humid subtropical climate and its ecosystem may be described as a Subtropical Dry Forest, the driest life zone of the six zones present in the Puerto Rico Platform. Culebra has a long dry season that extends from early spring to the end of summer, except for hurricane event interruptions, and a wetter fall and winter with occasional rain events. Culebra, due to the lower elevations of its hills, captures less moisture and rain events than sections of the neighboring islands. In contrast to the more elevated sections of Vieques, St. Thomas, St. John and some of the BVIs, Culebra does not have a subtropical moist forest zone of life area or rainforest. This has a significant impact on the flora composition of each of the islands.
Due to the limited rainfall there are no rivers or streams in Culebra. We can find a few drainage ponds naturally or constructed to control rain flows that also assist to control sedimentation and numerous dry drainage basins and retention ponds that activate during significant rain events. The drainage basins due to their function receive more water and retain some in small pools creating a limited enhanced vegetation zone. This condition, except during hurricanes and sporadic significant rain events, reduces the regular low river-carried sedimentation transportation into the surrounding coast. This climatic ecosystem without river flows creates the conditions for Culebra to enjoy very clean beaches with crystalline water. The beach of Playa Flamenco in the northwest tip, for example, has the largest retention lagoon in Culebra created by its sand dune natural barriers. The lagoon was originally, a longer shallow bay that naturally protects the beach and its water from the drainage and sedimentation of the surrounding hills and thus helped create one of the world’s cleanest beach waters.

**Ecological Associations: **

As previously mentioned, Culebra is classified as a Subtropical Dry Forest, the driest life zone of the six zones present in the Puerto Rico Platform. Three distinct ecological associations are clearly identified within the site. They are described as (i) the cliff association, (ii) the dry forest association and (iii) the grassland or herbaceous association. The three associations are interconnected as an ecosystem whole.
The cliff association is found in the extreme southern area of the property where significant seashore cliffs roll down to Playa Cascajo. This cliff association, as its names describes, is characterized by extreme cliff contours and narrow coastal areas.

A particular characteristic of the dry forest association, that prevails throughout the interior hillside of VMT and Culebra, is the low density and high separation between the small trees found in such terrain. Trees of some size and higher tree density may be noted generally in the hillside areas of the Green Valley particularly on south side of the central hill and to a lesser degree on the drainage basins of the northern side of the central hill. The protected Green Velley habitat including the south lower hill northern hillside basin areas that both drain southwest through the valley’s central basin toward Fulladosa Bay from the southern eastern half of the central hill of the VMT property. It should also be noted that the southern hillsides of both the central and south hills better protect established trees from the counterclockwise storm circulation and strong winds during hurricane events.
A notable characteristic of the grassland or herbaceous association is the fact that it is manifested throughout a significant portion of the VMT property; not only on the flatter top of the hills, throughout the central hill and southern and northern hill saddles and flat hilltop areas where the local vegetation was removed for cattle grazing, but also in areas where some smaller invasive trees have reestablished themselves.

The coastal area of Playa Cascajo, in VMT’s southern boundary, provides a proper habitat for coastal vegetation of the dry forest association. This habitat is limited by the seashore’s short depth and the
immediate steep cliff associations that are characteristic of the geography of the southern extension of the VMT site and Culebra generally. The beach area is not deep or sandy and is covered by rocks or dead coral and shells (“cascajo” in Spanish).

The “Cascajo” designation for the beach area describes its fractured stone, dead coral and seashell ground cover. Other limited areas of the island of Culebra provide wider coastal habitat extensions and even some sand dune areas allowing for better development of coastal habitat plants within such areas and also allowing, in some sandy beaches, turtle nesting areas.

Zone of Life (Humidity, Elevation and Diversity)

The Subtropical Dry Forest (SDF) Zone of Life in General: See Short Intro

The VMT site has been classified as subtropical dry forest (SDF). Water availability is one of the most important factors controlling species distribution in terrestrial ecosystems. “Rainfall seasonality is the most important characteristic of a SDF. During the wet season the SDF receives more than 70% percent of annual precipitation within the five months of the late summer and fall when rainfall averages more than 100 millimeters (2.54 inches) per month which allows for the development of a dense, if rather short in stature (10 to 15 meters high), forest-type vegetation. (Holdridge et al. 1995) In contrast, during the dry spring season, average monthly rainfall is less than 10 millimeters (.254 inches), creating conditions so dry that most trees, [and shrubs and vines] drop their leaves as a mechanism to deal with the lack of water.”

The mean annual temperature in a SDF is typically greater than 17 degrees Celsius or 32 degrees Fahrenheit. During the winter season, the average temperature in Culebra is 74 degrees Fahrenheit with November through April being the cooler months. During the summer season, from June to September, temperatures average 90 degrees Fahrenheit. Rain patterns in an SDF classified zone varies from 250 to 2000 millimeters (9.84 inches to 79.84 inches) annually, and an annual ratio of potential evapotranspiration to a precipitation of less than 1.0. However, by far the most distinctive characteristic of this dry forest life area is its seasonality, with four to six dry months (rainfall less than 100 millimeters), which in turn determines the distinctive phenology of the vascular plants and the forest as a whole; alternating deciduousness during the dry season, followed by an evergreen physiognomy during the rainy season. SDF zones are also subject to high inter-annual rainfall variability.

**The VMT Subtropical Dry Forest (SDF) Zone of Life:**

From the introduction to this section and the general descriptions of the Puerto Rico Platform and the geology and climate of Culebra, the reader can begin to get a better understanding of why, in an introduction to the Flora of Culebra, they are also getting a short introductory course not only on Geology and Climatology but to Plant Biology.

Culebra and the VMT site, as a subtropical dry forest (“SDF”), falls to the center of the extremes of SDF zones of life, temperature and rainfall ranges as explained in the prior Hydrology, Watersheds, Streams and Surface Waters sections.

To make Culebra’s climatic zone of life ecosystem even more challenging for the propagation and establishment of a species, the VMT geology presents additional habitat extremes. To start, as discussed in the earlier section on the Geology of Culebra, its soil series is shallow and can be generally found only to the depth of 1 foot to 1 ½ feet over the mother volcanic fractured rock base layers with greater topsoil depth in limited drainage and accumulation areas. About 70% of the surface of the VMT site is classified as Rs or Rock land soils as defined by the Soil Survey of the Humacao area of Puerto Rico prepared by the U.S. Department of Agriculture’s Soil Conservation Service. The surface of Culebra has a large as Rs or Rock land soils coverage. They are found in areas where rocks or rock formations may crop out on top of the soil by weathering on the surface many times covering up to 50 to 70 percent (50-70%)


58 Phenology is the study of periodic plant and animal life cycle events and how these are influenced by seasonal - annual variations in climate, as well as habitat factors (such as elevation). http://en.wikipedia.org/wiki/Phenology

59 Ibid.
Loose single stones, some very large, are also very common on the surface. Very shallow soil material lies between the outcrops and stones. The remaining VMT site has DeE2 soils with subclass of unit capacity of its DeE2 soil series classified as VIIe, which describes those soils that have severe limitations due to their rocky nature, shallowness and for their limited capacity to retain water and have a high annual ratio of potential evapotranspiration to precipitation of less than 1.0. Such extreme soil and growing habitat and environmentally hostile seasonality challenges the ecosystems process to be able to establishes a limited growth and development universe not only for the general living biota found in any SDF zone of life. More specifically, the extreme environment found in these areas further limits those species that can establish themselves and propagate in VMT and Culebra SDF zone of life.

The vegetation of Culebra and VMT’s SDF zone of life can be better described as more open (less dense), with trees, bushes, vines, and scrub that are semi-evergreen seasonally, a significant majority of said vegetation seasonally turns first yellow and then different tones of browns and grays as the leaves die and fall off the branches during the dry season. In instances, taller trees and large shrubs are widely spaced, growing between large boulders, on ridges, or within drainage basins. The prevalent small tree and shrub vegetation zones form a canopy of about 3 to 5 meters high. A few older and larger trees exceed the canopy and may grow up to 10 to 15 meters high. Note that use of the term “forest” is made only in the definitional context expressly utilized by Holdridge’s life zone system and is not intended to characterize the ecosystems within the area of study as a designated forest.

The vegetation of the SDF life zone tends to form a complete ground cover. Trees are usually less than 5 meters tall with broad-spreading flatter crowns. Many trees, shrubs, and vines in VMT become leafless during the dry season. Plants are generally small, succulent and predominantly leathery, many with thorns and spines and generally bisexual to allow for self-pollination to ensure reproduction and survival. Vegetative debris of dry leaves accumulates on the ground during the dry season, helping to enrich the soil but increasing fire hazards. Agriculture is marginal and requires irrigation to a level generally not available in many SDF life zone islands, such as Culebra. Grazing of cattle and goats is possible but requires a water trough. Goats can be very destructive to root systems of established plants, particularly in the herbaceous zone.

Six principal (dominant) species are present in this subtropical dry forest stratum: (1) Acacia farnesiana, (2) Prosopis pallida (an invasive species), (3) Bursera simaruba and (4) Bucida buceras, (5) Croton astroides and (6) Cordia dentata. Also present within this stratum in well-distributed amounts, is the cactus Pilosereus royenii.

The second, and only other predominant stratum present in the VMT site, is the herbaceous one, comprised of species that grow on the humus, which accumulates on the top of boulders, and also on the bare ground. This stratum represents the matrix of the overall area of study.

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Dominant species within this stratum include *Sida acuta*, *Commelina elegans*, *Jatropha gossypifolia*, *Mimosa casta*, and *Portulaca pilosa*.

Note that dominant species are listed herein to provide a characterization of the habitat within the area of study. Although many more species, particularly wayside plants and vines, populate the site, the mentioned species establish the overall ecological values of the site and provide a clear indication of the nature of the ecosystems within.

A plant species in danger of extinction is found in VMT. It is a cactus species identified as *Leptocereus grantianus* that is endemic to Culebra. It has been found in extensive areas of the South Hill fronting on Playa Cascajo within the VMT South Ecological Corridor. This major finding of *Leptocereus grantianus* in VMT is significant because it is protected in VMT South Ecological Corridor which reduces the risk of extinction of the species and assist in its long term survival.

The island of Culebra is located within the tropical hurricane zone and its flora is additionally subject to and periodically affected by such severe weather events during the July to October hurricane weather cycles. Extreme rainfall and its associated storm water drainage flows together with hurricane force winds can be very damaging to establish plants and their trunks, branch and leaf cover.

**Selection of Methodology for Fauna & Flora Evaluation of the VMT Proposed Project Site:**

(Expanded from VMT’s Flora and Fauna Assessment prepared by Environmental Consulting Group (ECG), 2009)

After evaluation and consideration of the characteristics of the site, an evaluation approach and methodology were designed for the assessment of the plants, birds, amphibians and reptiles inside the area of study, by implementing a qualitative research.

The first approach was to review the Scientific data of the U.S. Fish and Wildlife Service and the Department of Natural and Environmental Resources, and documents, including proposed actions, for species associated with the ecosystems in the area, as an overriding factor to make findings regarding the status of a listed species, the effects of a proposed action on the species or a critical habitat. A general description of the potential endangered species that could potentially be found in the habitat area follows:

**Endangered Species or/ and Threatened Species:**

Some species of flora and fauna were taken under consideration prior to the visit in order to establish whether they are present or not at the site and in accordance to the list of Endangered Species and the related habitat location.

The following sections include the species considered during our evaluation of the site.

**Reptiles:** V.I. Tree Boa (*Epicrates monensis granti*)

Culebra giant lizard (*Anolis roosevelti*)
Tinglar (Dermochelys coriacea)
Carey (Eretmochelys imbricate)
Peje Blanco (Chelonia mydas)

The Culebra giant lizard, *Anolis roosevelti*, is a brown grayish lizard with two distinctive white bands on the sides of its body and one white spot on each side of its head.

The V.I. Tree Boa, *Epicrates monensis granti*, is found on small islands, in cays and islets to the east of Puerto Rico. It is similar to *E. monensis*.

The Tinglar, *Dermochelys coriacea*, is the biggest turtle; it can measure up to 7.8 feet long and weight up to 1,485 pounds. It has oceanic habits and in periods of breeding and nesting approaches the coastal areas.

The Carey, *Eretmochelys imbricate*, measures 1 m more or less, and can weight up to 100 pounds. Probably is the most common turtle in the water of the Island, but its population is being reduced because of the hunting, egg collection, and alterations on the nesting beaches. These beaches are mainly within the Resaca, Brava and Larga beaches in Culebra, Cayo Norte in Culebra and beaches in Culebrita, already designated as critical habitat.

The Peje Blanco, *Chelonia mydas*, gets its name from its green fat color. Adults are most of the time vegetarian. In Puerto Rico it can be found in all waters but in a reduced number. The reduction of the population is mainly caused by the exploitation of its meat, loss of habitat for nesting, egg predation from man and other domestic animals and loss of surveillance for predation. Nesting in Mona, Culebra, Caja de Muertos, Manati, and other places. No critical habitat has been declared.

**Mammals:**  
Manatee (*Trichechus manatus*)

The manatee is an aquatic mammal from the order Sirineos. It can reach 9 to 13 feet, and weight 1,300 pounds more or less. Their habitat is in the surrounding coastal lower waters. It’s vegetarian and feeds from sea grasses specially *Thalassia* (Yerba de Tortuga).

Many factors such as boat accidents, destruction of underwater meadowlands by water contamination, and intentional fishing have helped to diminish its population.

**Birds:**  
Brown pelican (*Pelecanus occidentalis*)

Palometa (*Sternia dougallii*)

The pelicans, *Pelecanus occidentalis*, are grayish-brown colored with white head and chest, yellow eyes and black legs.
The palometa *Sterna dougallii*, is a medium size bird with white tail and neck, light gray back and wings and a black feather capped head.

**Flora: Cactus (Leptocereus grantianus)**

*Leptocereus grantianus* may reach up to 2 meters in height and from 3 to 5 centimeters in diameter. Its elongated stems have from three to five prominent ribs with broadly scalloped edges. Ribs of young joints are thin, and the small areoles or spine-bearing areas may bear from one to three minute, nearly black spines which disappear as the joints grow older. The flowers are solitary at terminal areoles, from 3 to 6 centimeters long, and nocturnal. The outer perianth segments are linear, green, and tipped by an areole like those of the tube and ovary. The inner perianth segments are numerous, cream-colored, oblong-obvate, obtuse, and about 8 millimeters long. The fruit is subglobose to ellipsoid and about 4 centimeters in diameter.

After carrying the scientific site evaluation in accordance to established methodology described in the 2009 *Flora and Fauna Assessment*, the scientist and biologist that carried out the detailed field study for a second time, [a first Flora and Fauna study had been carried out by them in 2003] in regard to potential endangered Fauna and Flora species came to the following conclusion:

“**Conclusion of Findings of Flora and Fauna Assessment, 2009**

6.1 **Endangered species**

After evaluation of the data collected in the area of study there is evidence to support the presence of only one endangered species listed [emphasis added] by the U.S. Fish and Wildlife Service. The species of concern is the cactus *Leptocereus grantianus* present within the cliff association.

The personnel of the US Fish and Wildlife Service have prepared a Recovery Plan for the preservation and recovery of the species.

Among the most relevant aspects of this Recovery Plan are the following.

Description of *Leptocereus grantianus* (Cactaceae)

*Leptocereus grantianus (Cactaceae)* is a sprawling, sub-erect, nearly spineless cactus which may reach up to 2 meters in height and 3 to 5 centimeters in diameter. The elongated stems have 3 to 5 prominent ribs with broadly scalloped edges. Ribs of young joints are thin, and the small areoles may bear one to three minute, nearly black spines which disappear as the joints grow older and the ribs become thicker.

The flowers are solitary at the terminal areoles, 3 to 6 centimeters long, and nocturnal. The ovary and flower tube bear distinct areoles. The outer perianth segments are linear, green and tipped by an areole like those of the tube and ovary. The inner perianth segments are numerous, cream-colored, oblong-
ovate, obtuse and about 8 millimeters long. Stamens are many and have yellow anthers. The stigma lobes are several and short. The fruit is subglose to ellipsoid and about 4 centimeters in diameter.

This cactus is endemic to Culebra, an island located just off the northeastern corner of Puerto Rico. On Culebra Leptocereus grantianus grow on rocky, steep slopes adjacent to the narrow beach. Associated species on this rocky slope are almácigo (Bursera simaruba), úcar (Bucida buceras), uva de playa (Coccoloba uvifera), sebucán (Pilosocereus royenii) and mesquite (Prosopis pallida).

The species is threatened by intense pressure for rural, urban, and tourist development, as well as by its location on a rocky, unstable shoreline approximately 8 to 10 meters from high tides.

**Recovery Objective:**

The objective of the recovery plan is to provide for reversing the decline of Leptocereus grantianus and for restoring the species to a self-sustaining status, thereby permitting it to be removed from the Federal Endangered Species List.

**Leptocereus grantianus** may be considered for down listing when (1) an agreement among the Fish and Wildlife Service, the municipality of Culebra, and the Puerto Rico Department of Natural and Environmental Resources (DNER) has been prepared and implemented for the protection of the species, and (2) new populations capable of self perpetuation have been established within units of the Culebra National Wildlife Refuge.

**Actions Needed:**

Protect the existing population and its habitat through an agreement with private landowners, the municipality of Culebra, and the Department of Natural and Environmental Resources.

Develop a management plan for the species in cooperation with these entities.

Monitor known populations.

Enforce existing Commonwealth and Federal endangered species regulations.

Educate the public on conservation values and regulations.

Conduct research on the life history of the species and evaluate propagation techniques.

Conduct propagation and enhance existing populations or establish new ones on lands within the Culebra National Wildlife Refuge.

**Leptocereus grantianus** was determined to be an endangered species on February 26, 1993, pursuant to the Endangered Species Act of 1973, as amended. Critical habitat has not been designated for this species because of the risks of vandalism as well as its potential for over collection, for use as an ornamental.”
Ecological Value:

The hillside cliff association of the VMT site provides the conditions for nesting, breeding and feeding for most of the birds, reptiles, insects, certain crustaceans and other fauna. It also provides the habitat for the Leptocereus grantianus cactus. Culebra has a small local population of birds, a migratory bird population and a small fauna density. Trees and larger shrubs provide a place for nesting and feeding and provide protection from wind erosion. Most of the species stay within the area of the cliff because it provides the major life support necessities. Birds move along the site to and from other areas.

Vegetative communities have been significantly disturbed by natural and human processes which significantly removes native established flora. Many areas on top of the hills are flatter and have been cleared for cattle grazing during the early and mid 1900s. The grass and shrub area upon repopulation has been significantly covered by Aroma – Cassie (Acacia farnesiana) and invasive Bayahonda - Mezquite (Prosopis juliflora). The Mezquite first arrive to Culebra via St. Thomas in the cow dung of cattle imported from Texas during the early twentieth century. Few reptiles use the cleared disturbed site areas as a natural habitat even during the repopulation period.

The coral and grass areas in the Playa Cascajo oceanfront area lie outside of the proposed project site and are being protected by the VMT South Ecological Corridor and the relocation of home sites. The long established R0-1-C zoning permits 58 residential home sites on the oceanfront of the southern hill. Except for three single family home sites, the rest are being relocated to disturbed areas of the site and other less environmentally sensitive and to protect the Playa Cascajo area.

Interactions on the Flora Habitat Area with Zones of Life:

The zone of life and site’s vegetation has already been described as a less dense, semi-evergreen seasonal dry forest. In instances, larger trees and shrubs are widely spaced, growing between large boulders, on ridges, or within drainage basins and contour patterns, creating a vegetative canopy of about 3 to 5 meters. The cliff association also harbors Culebra’s unique endangered Leptocereus grantianus cactus. Loose single stones are also very common on the soil’s surface, indicating historical degradation of volcanic formations and sediment on the predominant Rock land (Rs) series hilly surface. Very shallow soil material lies between the stone outcrops and volcanic island base.

The extended dry season causes Culebra’s dry subtropical forest to turn a straw-like, yellow-brown color as the vines and shrubs dry up and loosen their leaves. This process naturally clears the forest and ground areas of vegetation except for the accumulation of dry vegetative leaves and debris. During the dry season cycle, it is curious to note how clearly you can see through the scant dry shrubs and tree cover to observe and study the terrain features on the hillsides and the exposed ground that has been naturally left without any significant vegetative ground cover. This cycle and view reverse during the rainy season as excess water and nutrients cause the island to become green and the vegetation seems to explode with leaves and flowers, pointing to a rich nutrient base and strong resilient natural xerophitic flora.
The flora of the Culebra study area was widely disturbed by human interventions by prior owners and occupants of the forest and pasture associations and the littoral (cliff) association. Large tracts of the land area in Culebra and VMT were used for many years as cattle grazing land with associated pastures. The invasive but excellent grass feed plant for cattle, *Panicum maximum* Jacq., Yerba de Guinea - Guinea grass was introduce and has become a menace since it has strong roots and is a profissious seeder that survive and are transported by bush fire that periodically affect Culebra during the dry season. The regeneration of trees and denser vegetation in these areas has not been significant due to the rock land characteristic of the soil associations and shallow soils prevalent in Culebra.

The zones of life and climatic conditions found in the disturbed areas of this subtropical dry forest stratum extends the establishment period for a new plant to be able to relocate and establish itself and start recapturing or expanding in the previously disturbed life zone. These agricultural and grazing disturbed sites when abandoned are quickly repopulated with naturalized invasive grasses, roadside weeds, secondary bushes, naturalized vines and climbing lianas and tress such as Guinea grass, Aroma – Cassie and the invasive Bayahonda – Mesquite.

These aggressive invasive plants are generally of rapid growth and are typically found in areas of disturbed vegetation, such as abandoned farms, road an access road sides, pastures, or secondary forests and thickets. This regenerated vegetation has limited value for, in effect, it impedes the regeneration of local established species and continues to limit their territorial development. The human habitation and grazing use was additionally aggravated by significant portions of Culebra and Vieques and adjacent cays being used for three quarters of a century for naval bombing, explosive munitions and war exercises creating additional permanent disturbances. The flatter hilltop areas are under influence of the wind, creating an environment of high energy which is periodically aggravated by the annual hurricane force winds which creates a habitat favorable for certain species only.

Environmental and climatic historic change has been dramatic in the Northeastern Geologic Platform Bank of the Greater Antilles Arc, where cooler climates prevailed some 15,000 to 20,000 years ago, which required the vegetation to adapt within their habitats as the climate evolved into the moist dry climate we live today.

Only certain patterns of land use, settlement and development, building construction, or xerophitic landscape design are compatible with local and regional hydrology and geomorphic conditions as well as biogeochemical cycles. A cooler mustier condition seems to be evolving, but again, depending on the Niño phenomena, we see it reverse to hotter drier cycle as is happening in the last three years. These dramatic environmental changes also result from human habitation, agricultural activities, deforestation, harvesting and removal of endemic vegetation. The introduction of many non-indigenous plants from other xerophitic tropical and non-tropical areas and exotic fauna has fragmented fauna and flora associations. The human habitation and predominant development of grazing pursuits in Culebra and goat grazing during the past century have greatly changed the ecosystem and the composition of native plants and animals in Culebra and the rest of the platform. Feral cats that can be observed throughout the entire site and other invasive fauna, such as goats and deer, have a significant degradation effect on flora and fauna. The deer eat the leaves of exposed young Bursera simaruba,
Almacigo -Turpentine trees and many other species clipping with their teeth their upper young trunk with consequent damage to its growth or establishment. Natural processes such as earthquakes, hurricanes, fires and land degradation continuously also shape the natural environment.

In terrestrial systems, unsound land-use and land-management practices lead to or further aggravate natural soil loss or degradation, reduce the long term potential productivity of a site, and can affect species composition. Additions of water and nutrients may exceed levels that can be used directly by primary producers, given the natural limitations of species and climate. The excess water and nutrients from enriched systems naturally move into adjacent areas and influence ecosystems by such processes as runoff. This is the base natural habitat of the ecosystems including the receiving drainage basins and bodies of water and life systems. It is a long term historical geologic and habitat forming process.

To prevent additional degradation, Best Management and Engineering Practices (BMPs and BEPs) have been applied throughout the VMT property to reduce and control natural erosion and minimize the impact of uncontrolled storm-water runoffs on the habitats and drainage systems. The speed of storm water flows has been substantially reduced with pre-detention and detention catch basins and ponds. Sediment and soil transfer has also been substantially reduced and topsoil recovery is occurring to regenerate planting areas. Similarly, sustainable human settlement and site development is limited to suitable places on the landscape and clustered to the sides to allow for a contiguous green vegetation corridor and to protect the more sensitive areas and the Playa Cascajo seashore and seafront zones. Sustainable development that limits penetration, disturbances and reduces, collects, and controls excess water flows for human inhabitant use and irrigation, helps reduce the rapid flows of excess water and soil nutrients in cliff associations. These degrading flows from such enriched systems have naturally occurred for years throughout Culebra. The re-use of grey water for irrigation assist xerographic vegetation establish and repopulate by self-propagation particularly during the extended dry season.

The spatial array of habitats or ecosystems comprises the landscape, and all ecological processes respond, at least in part, to this ecological landscape template presented not only in VMT, but generally throughout Culebra’s land sites. The kinds of organisms that can exist (including their movement patterns, interactions, and influence over such ecosystem processes, such as decomposition and nutrient fluxes) are constrained by the sizes, shapes, and patterns of interspersion of habitat across the landscape. As established habitats are divided and fractioned, the ecosystem suffers degradation. Large decreases in the size of habitat patches, or increases in the distance between habitat patches of the same type, can greatly reduce or eliminate populations of organisms as well as alter ecosystem and habitat processes. 61

These realities made it essential that VMT adopt Design and Development Guidelines very early in the design process. The proposed strategy for the development’s concentration of new structures on


See also: 1.2.5 Landscape Principle, excerpt from the book: Applying Ecological Principles to Land Management, edited by Virginia H. Dale, Richard A. Haeuber
previously disturbed land, side-clustering and relocation strategies, as well as its unusually large proposed protected and conserved land areas and set-asides, harmonizes with the ecosystem and does not present significant disturbances to these patterns. The project’s sustainable goals and advanced design system to collect rooftop water into cisterns, use photovoltaic power collection, apply best stormwater control techniques and engineering practices, and the introduction of detention ponds to detain and control excess storm flows, significantly assist in the control and reduction of naturally occurring soil degradation, sedimentation loss and discharge. The proposed extraordinary set-aside of almost 70% of the landsite into the VMT Ecological and Continuous Corridors sets a new higher goal and model for future development on the island.

Large decreases in the size of habitat patches, or increases in the distance between habitat patches of the same type, can greatly reduce or eliminate populations of organisms as well as alter ecosystem and habitat processes. Nonetheless, the proposed development’s building on disturbed land, clustering and relocation strategies and its unusually large proposed protected and conserved land area and set-asides, harmonizes with the ecosystem and does not present significant disturbances to these patterns. The project’s sustainable goals and advanced design system to collect rooftop water into cisterns, the application of best storm-water control techniques and practices, and the introduction of detention ponds to detain and control excess storm flows, significantly assist in the reduction of naturally occurring degradation. The proposed extraordinary set-aside of 70 cuerdas into the VMT Ecological Corridors sets a new high goal and model for future development on the island.

Human-settlement patterns and individual land use decisions often fragment the landscape or otherwise alter land cover patterns. Habitat connectivity can also constrain the spatial distribution of species by making some areas accessible and others inaccessible. Connectivity is a threshold dynamic, meaning that gradual reduction of habitat may have gradual effects on the presence or abundance of a species, but the effects tend to be dramatic after the threshold is passed. Landscape fragmentation is not necessarily destructive of ecological function or of diverse biological communities because a patchwork of habitat types will often maintains more types of organisms and more diversity of ecosystem processes than would a large area of homogeneous habitat.

Significant green habitat areas and contiguous corridors are being set aside and protected in the VMT South Ecological Corridor and North Contiguous Green Corridor to provide interconnectivity and avoid fragmentation. Making a naturally patchy landscape less patchy (more uniform) may also have adverse effects. The interconnectivity of the contiguous reserve corridors and protected easement areas helps to prevent the downgrading effect of patching on the habitats. The streams corridors covered by vegetation assist in the interconnectivity. The ecological importance of a habitat patching may be much greater than is suggested by its spatial extent. Some habitats, such as bodies of water or riparian corridors, are small and discontinuous, but nevertheless have ecological impacts that greatly exceed their spatial extent. For example, wetlands and bodies of water in general are low in spatial extent but high in their contributions to the compositional and structural complexity of an eco-region.

Larger patches of habitat generally contain more species (and often a greater number of individuals) than smaller patches of the same habitat. Larger patches also frequently contain more local environmental variability, such as differences in microclimate, more structural variation in plants, and
greater diversity of topographic positions. This variability provides more opportunities for organisms with different requirements and tolerances to find suitable sites within the patch. In addition, the edges and interiors of patches may have quite different conditions, favoring some species over others, and the abundance of edge and interior habitat varies with patch size. Large patches are likely to contain both edge and interior species, whereas small patches will contain only edge species. In Culebra the significant similarity of microclimate and topographic condition reduces the large patching diversification tendency.

Land-cover changes are most likely to have substantial effects when habitat is low to intermediate in abundance. Under these conditions, small changes in habitat abundance may cause the connectivity threshold to be passed. The threshold of connectivity varies among species and depends on two factors: (1) the abundance and spatial arrangement of the habitat and (2) the movement or dispersal capabilities of the organism. Habitat reforestation and enrichment of species being currently implemented under present and future Partners Program or similar pursuits with the USFWA, DRNA and other environmental and conservation entities can help prevent degradation and enhance development of the flora communities.

Local ecological dynamics (e.g., the abundance of organisms at a place) may be explained by attributes of the surrounding landscape as well as by characteristics of the immediate habitat locale. The density and abundance of species found and the rates of immigration and extinction of species in habitat patches will be affected by competition from other species and by habitat structure. Therefore, understanding the implications of local land-use decisions requires interpreting them within the context of the surrounding landscape.

Management, Categorization and Classification of the Natural Habitats of the Protected Areas of the VMT Ecological Corridors under International IUCN Classifications and PR DRNA Regulations: [New]

The aggregate set-aside of the areas in the VMT South Ecological Corridor and North Contiguous Green Corridor is one of the FMT nuclear goals and of the VMT’s proposed sustainable and recreational tourism model community. The fulfillment of this goal of creating a relatively large dedicated conservation protected area to be used and be perpetually available for nature appreciation, educational and scientific purposes establishes a new model and standard of development that uniquely voluntarily sets-aside 70% of the proposed development site. They will provide a palpable example and model guidelines and set standards of sustainable “green development” for Culebra and worldwide ecological conservation.

These habitat management measures allow for managed model contiguous protected area and plenty of undisturbed and regenerated land to pursue the conservation, educational, scientific and reforestation and regeneration goals of FMT, now in the new role of being the “Ecological Foundation”. In order to properly manage in a sustainable manner the ecologic corridors set-aside areas the side areas had to be designated and classified both under international and DRNA Commonwealth of Puerto Rico habitat categorization standards.

The International Union for Conservation of Nature (“UICN”) helps the world find pragmatic solutions to our most pressing environmental and development issues. UICN is recognized for its responsible
leadership and its standards applied world-wide. **UICN** is the world’s oldest and largest global environmental organization, with more than 1,200 government and NGO Members and 11,000 volunteer experts in some 160 countries. **UICN’s** work is supported by over 1,000 staff and 45 offices and hundreds of partners in public, NGO and private sectors around the world.

In September 2003, the Puerto Rico DRNA, through the Bureau of Fisheries and Wildlife (BFW), initiated the development of the **Critical Wildlife Categorization Standards** (CWCS) for Puerto Rico.

**UICN Protected Areas Categories System:**

**UICN Protected Areas Categories** classify protected areas according to the management objectives. The categories are recognized by international bodies such as **United Nations** and by many national governments as the global standard for defining and recording protected areas and as such are increasingly being incorporated into national legislation. These category standards were established originally in 1994 and were amended as recently as 2008 in international meetings.

**UICN Protected Area Categories System**[^62]:

UICN protected area management categories classify protected areas according to their management objectives as follows:

**Ia Strict Nature Reserve**

- **Category Ia** are strictly protected areas set aside to protect biodiversity and also possibly geological/geomorphical features, where human visitation, use and impacts are strictly controlled and limited to ensure protection of the conservation values. Such protected areas can serve as indispensable reference areas for scientific research and monitoring ... ;

**Ib Wilderness Area**

- **Category Ib** protected areas are usually large unmodified or slightly modified areas, retaining their natural character and influence without permanent or significant human habitation, which are protected and managed so as to preserve their natural condition;

**II National Park**

- **Category II** protected areas are large natural or near natural areas set aside to protect large-scale ecological processes, along with the complement of species and ecosystems characteristic of the area, which also provide a foundation for environmentally and culturally compatible, spiritual, scientific, educational, recreational, and visitor opportunities. **III Natural Monument or Feature**

- **Category III** protected areas are set aside to protect a specific natural monument, which can be a landform, sea mount, submarine cavern, geological feature such as a cave or even a living feature such as an ancient grove. They are generally quite small protected areas and often have high visitor value.

• **IV Habitat/Species Management Area**

**Category IV** protected areas aim to protect particular species or habitats and management reflects this priority. Many Category IV protected areas will need regular, active interventions to address the requirements of particular species or to maintain habitats, but this is not a requirement of the category.

**V Protected Landscape/ Seascape**

**Category V** protected area where the interaction of people and nature over time has produced an area of distinct character with significant, ecological, biological, cultural and scenic value: and where safeguarding the integrity of this interaction is vital to protecting and sustaining the area and its associated nature conservation and other values.

**VI Protected area with sustainable use of natural resources**

**Category VI** protected areas conserve ecosystems and habitats together with associated cultural values and traditional natural resource management systems. They are generally large, with most of the area in a natural condition, where a proportion is under sustainable natural resource management and where low-level non-industrial use of natural resources compatible with nature conservation is seen as one of the main aims of the area more....

**Categories of Special Interest to Villa Mi Terruño:**

**Protected Areas Category IV**

Protected areas aiming to protect particular species or habitats with management reflect this priority. Many category IV protected areas will need regular, active interventions to address the requirements of particular species or to maintain habitats, but this is not a requirement of the category.

**Primary objective:**

To maintain, conserve and restore species and habitats.

**Other objectives:**

- To protect vegetation patterns or other biological features through traditional management approaches;
- To protect fragments of habitats as components of landscape or seascape-scale conservation strategies;
- To develop public education and appreciation of the species and/or habitats concerned;
- To provide a means by which the urban residents may obtain regular contact with nature.

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[63](http://www.iucn.org/about/work/programmes/gpap_home/gpap_quality/gpap_pacategories/gpap_category4/)
**Distinguishing features:**

*Category IV* protected areas usually help to protect, or restore: 1) flora species of international, national or local importance; 2) fauna species of international, national or local importance including resident or migratory fauna; and/or 3) habitats. The size of the area varies but can often be relatively small; this is however not a distinguishing feature. Management will differ depending on need. Protection may be sufficient to maintain particular habitats and/or species. However, as category IV protected areas often include fragments of an ecosystem, these areas may not be self-sustaining and will require regular and active management interventions to ensure the survival of specific habitats and/or to meet the requirements of particular species. A number of approaches are suitable:

- Protection of particular species: to protect particular target species, which will usually be under threat (e.g., one of the last remaining populations);
- Protection of habitats: to maintain or restore habitats, which will often be fragments of ecosystems;
- Active management to maintain target species: to maintain viable populations of particular species, which might include for example artificial habitat creation or maintenance (such as artificial reef creation), supplementary feeding or other active management systems;
- Active management of natural or semi-natural ecosystems: to maintain natural or semi-natural habitats that are either too small or too profoundly altered to be self-sustaining, e.g., if natural herbivores are absent they may need to be replaced by livestock or manual cutting; or if hydrology has been altered this may necessitate artificial drainage or irrigation;
- Active management of culturally-defined ecosystems: to maintain cultural management systems where these have a unique associated biodiversity. Continual intervention is needed because the ecosystem has been created or at least substantially modified by management. The primary aim of management is maintenance of associated biodiversity. Active management means that the overall functioning of the ecosystem is being modified by e.g., halting natural succession, providing supplementary food or artificially creating habitats: i.e., management will often include much more than just addressing threats, such as poaching or invasive species, as these activities take place in virtually all protected areas in any category and are therefore not diagnostic. *Category IV* protected areas will generally be publicly accessible.

**Issues for consideration:**

- Many *category IV* protected areas exist in crowded landscapes and seascapes, where human pressure is comparatively greater, both in terms of potential illegal use and visitor pressure.
- The *category IV* protected areas that rely on regular management intervention need appropriate resources from the management authority and can be relatively expensive to maintain unless management is undertaken voluntarily by local communities or other actors.
- Because they usually protect part of an ecosystem, successful long-term management of *category IV* protected areas necessitates careful monitoring and an even greater-than-usual emphasis on overall ecosystem approaches and compatible management in other parts of the landscape or seascapes.
Protected Areas Category V

A protected area where the interaction of people and nature over time has produced an area of distinct character with significant ecological, biological, cultural and scenic value: and where safeguarding the integrity of this interaction is vital to protecting and sustaining the area and its associated nature conservation and other values.

**Primary objective:**

To protect and sustain important landscapes/seascapes and the associated nature conservation and other values created by interactions with humans through traditional management practices.

**Other objectives:**

- To maintain a balanced interaction of nature and culture through the protection of landscape and/or seascape and associated traditional management approaches, societies, cultures and spiritual values;
- To contribute to broad-scale conservation by maintaining species associated with cultural landscapes and/or by providing conservation opportunities in heavily used landscapes;
- To provide opportunities for enjoyment, well-being and socio-economic activity through recreation and tourism;
- To provide natural products and environmental services;
- To provide a framework to underpin active involvement by the community in the management of valued landscapes or seascapes and the natural and cultural heritage that they contain;
- To encourage the conservation of agrobiodiversity6 and aquatic biodiversity;
- To act as models of sustainability so that lessons can be learnt for wider application.

**Distinguishing features:**

Category V protected areas result from biotic, abiotic and human interaction and should have the following essential characteristics:

- Landscape and/or coastal and island seascape of high and/or distinct scenic quality and with significant associated habitats, flora and fauna and associated cultural features;
- A balanced interaction between people and nature that has endured over time and still has integrity, or where there is reasonable hope of restoring that integrity; (emphasis supplied)
- Unique or traditional land-use patterns, e.g., as evidenced in sustainable agricultural and forestry systems and human settlements that have evolved in balance with their landscape.

**Issues for consideration:**

- Being a relatively flexible model, Category V may sometimes offer conservation options where more strictly protected areas are not feasible.

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64 http://www.iucn.org/about/work/programmes/gpap_home/gpap_quality/gpap_pacategories/gpap_category5/
Category V protected areas can seek to maintain current practices, restore historical management systems or, perhaps most commonly, maintain key landscape values whilst accommodating contemporary development and change: decisions about this need to be made in management plans.

The emphasis on interactions of people and nature over time raises the conceptual question for any individual category V protected area: at what point on the temporal continuum should management focus? And, in an area established to protect values based on traditional management systems, what happens when traditions change or are lost?

Since social, economic and conservation considerations are all integral to the category V concept, defining measures of performance for all of these values is important in measuring success.

As people are the stewards of the landscape or seascape in category V protected areas, clear guidelines are needed about the extent to which decision making can be left to local inhabitants and how far a wider public interest should prevail when there is conflict between local and national needs.

How is category V distinguished from sustainable management in the wider landscape? As an area with exceptional values? As an example of best practice in management? Category V is perhaps the most quickly developing of any protected area management approaches.

There are still only a few examples of the application of category V in coastal and marine settings where a “protected seascape” approach could be the most appropriate management option and more examples are needed (see e.g., Holdaway undated).

Wildlife Laws and Regulations of Puerto Rico:

DNER Protected Areas Categories System:

In September 2003, the Puerto Rico DRNA, through the Bureau of Fisheries and Wildlife (BFW), initiated the development of the Critical Wildlife Categorization Standards (CWCS) for Puerto Rico. Active collaboration between DNER, the US Fish and Wildlife Service, universities, and several NGOs was the key to produce a first draft of the CWCS. A PDF version of this document was available for public revision and comments at the DNER website (www.drna.gobierno.pr).


The information about threats, taxa population numbers, current distribution, and reason for categorization are included for each species. The DNER adapted the following five categories from the International Union for the Conservation of Nature (IUCN) Red List (1994) to classify those priority species (Table 1). See appendix I for detailed category definitions.


2. Endangered (EN): A species is endangered when it is not CR, but faces a very high risk of extinction in the wild in the near future.
3. **Vulnerable (VU):** A species is vulnerable when it is not CR or EN, but it faces a high risk of extinction in the wild in a foreseeable future.

4. **Low Risk (LR):** A species is at low risk when, after an evaluation, it did not satisfy any of the previous categories (CR, EN, or VU) and it is not Data Deficient.

5. **Data Deficient (DD):** A species fall under to this category when there is not enough information for a direct or indirect assessment of its risk of extinction based on its distribution and/or population status. Some aspects of the ecology of a species in this category may be well studied and its biology might be well known, but appropriate data about its abundance and distribution may be lacking. Therefore, Data Deficient is not a threat category.

The objective of this **CWCS**\(^65\) is **(1)** to identify the status of the species and their habitats, **(2)** to identify conservation priorities for these species and their habitats, and **(3)** to establish a regular monitoring process aimed at updating the previous two objectives. The CWCS considers the broad range of Puerto Rico’s wildlife with appropriate emphasis placed on species/habitat with the greatest conservation needs, especially on **Data Deficient (DD)** species. The strategy also contemplates the funding available for the conservation of those species.

**Habitat Conservation and Protection Wildlife Habitat** is evaluated and characterized according to the categories established in Regulations No. 6765 and 6766. The **DNER** Secretary designates endangered and threatened species habitat as **Critical Habitat (CH)** or **Critical Essential Habitat (CEH)**. The CEH cannot be modified unless a change in designation is supported by scientific data. For instance, a CH may be modified only if the proposed action has a vital public interest and there is no other option. Any alteration to a CH will require a mitigation of at least a 3:1 proportion with habitat of same or higher ecological value.

**Comprehensive Wildlife Conservation Strategy Puerto Rico:** The DNER-TRD evaluates the potential impact that development will have on our wildlife species and their habitats. Personnel from this Division provide technical guidance about proposed actions in accordance with regulations. The action to be implemented will depend upon the habitat designation (Table 8)\(^66\).

**Table 8:** Wildlife habitat categories and actions proposed to deter habitat loss.

<table>
<thead>
<tr>
<th>Habitat Category</th>
<th>Protection Action</th>
<th>Critical Essential</th>
<th>Endangered/Threatened Species (only known locality)</th>
</tr>
</thead>
</table>


\(^66\) Ibid, p. 140
No Modification Critical Endangered/Threatened Species (Natural or Historical distribution) (Reintroduction Potential) Restricted Modification Requires a 3:1 or higher habitats compensation (mitigation)

Irreplaceable All Wildlife No Net Loss Essential All Wildlife No Net Loss or in situ or adjacent 1:1 compensation High Ecological Value All Wildlife No Net Loss or in situ or adjacent 1:1 compensation

Ecological Value All Wildlife No Impact or in situ, adjacent or off-site 1:1 compensation

High Potential All Wildlife Mitigation through habitat enhancement or land acquisition

Low Potential All Wildlife Mitigation through habitat enhancement and other actions that improve habitat conditions Technical Assistance for Wildlife Conservation in Puerto Rico.

Corridor Management Considerations and Classifications:

Prior to commencement of the Project the development shall subscribe and execution the corresponding public deeds before a Notary Public to (1) establish and describe the rectified title of the Project including the delimitation of the Maritime and Land Zone Boundaries, (2) to establish the infrastructure easements, (3) present in the Registry of Plans in the Registry of Property the site Urbanization Development Plan, (4) execute the corresponding Deed of Constitution of the Establishment of the Restrictive Perpetual Conservation Easements and Donation and Transfer of the Conservation Corridors, previously generally described, and (5) the construction Restrictive Construction Covenants deed. The transfer and donation of the Ecological Corridors to the Ecological Foundation in action (4) shall establish and be subject to the corresponding Conservation Easements, Use and Management and other use conditions.

The Deed of Constitution of the Establishment of the Restrictive Perpetual Conservation Easements and Donation and Transfer of the Conservation Corridors to the Ecological Foundation shall provide the management requirements and guidance that the Ecological Foundation shall be required to comply. The Ecological Foundation shall be required to properly observe the guidelines and use and management requirements and recommendations established by the UICN and DNER under the proper designated as categories as established in the Deed.

The Leptocereus grantianus and Epicrates monensis granti habitats shall be classified and manage under UICN habitat Category IV Guidelines and DNER habitat Category III, due to their endangered species status. The rest of the South Ecological Corridor should be managed under UICN habitat Category IV Guidelines and DNER habitat Category IV. The rest of the Ecological Corridor and protected areas should be managed under UICN habitat Category V Guidelines and DNER habitat Category IV and V. The final DNER habitat classifications are pending and being requested under the construction and urbanization permitting requirements.
**VMT Flora Habitat Protection and Restoration Plan:**

The proposed development’s VMT Master Plan and Guidelines provide for numerous measures to avoid or ameliorate the potential negative impact on the vegetation areas and habitat development. Significant boulders and terrain features in the proposed construction site have been considered and site use and design adapted according to recommendations from the federal and local environmental agencies and applicable sustainable development literature. The placement of the homes considers terrain contours, green corridors and natural element found at and around the home sites. Most of the home sites and the tourism lodges and camps have been clustered around the larger historically disturbed tracts of the land that were used for many years as cattle grazing land with associated pastures. We have already indicated that the regeneration of trees and denser vegetation in these areas has not been significant due to the rock land characteristic of the soil associations and shallow soils prevalent in Culebra. The zones of life and climatic conditions found in these disturbed areas extends the period for a new plant to establish itself and start recapturing the life zone. Accordingly these disturbed areas are more suitable for development because the new construction has no significant impact on areas invasive and non-significant vegetation. The use of the existing access roads with minimum habitat invasion versus developing new access roads is another prime consideration of the design plan. The consideration of the environment and protection of contiguous vegetation starts with the master planning and continues throughout development, construction and operation. Barriers to protect significant vegetation outside construction site boundaries will be installed including BMPs and BEPs to help control runoffs.

In addition, a reforestation program with local native species is being developed and will continue to be enhanced. A restoration nursery, recently completed in 2014 under the Partners Program with the USFWS, will aid in plant propagation efforts. Reforestation and plant establishment has already started to be carried out during the predevelopment period. Knowledge has been acquired and accumulated as to the live zoning and planting, cultivation and watering efforts needed to assist a plant or tree to establishment and to deeply root and be able to establish itself independently and survive the extended dry hot season. Culebra has been known to go without rain for periods exceeding five to ten weeks during the late spring and midsummer months before hurricane weather cycles that bring periodic or significant rain and moisture.

Plant material shall be selected by studying the existing natural flora and its characteristics as well as their site placement over the past decade. The endangered cactus will be protected in reserve areas and propagated to establish new populations that will also provide suitable habitat for other potentially present species. This practice has been strictly carried out during pre-development in coordination with the USFWS. Restoration and reforestation programs are already underway. The greenhouse nursery on-site is helping to help propagate the endangered cactus and other significant native endemic vascular flora. Propagation from seeds of local endemic flora has been rapidly expanded in the Greenhouse. The Greenhouse also received on the 26th of February, 2014, the 1,260 established trees and shrubs to be
used to enhance and reforest the VMT Subtropical Model Dry Forest after the plants spend a period maturing and acclimating in the VMT Greenhouse.

Welcome to the Culebra Flora Habitat Introduction Site:

Nature is a God-given gift to be enjoyed, shared, and conserved for our future generations. The subtropical Flora of Culebra affords visitors and residents of the island a unique opportunity to enjoy a very special personal experience of both visual and spiritual dimensions.

The FMT Culebra Flora and Fauna Digital Photographic Databases are published by FMT, with special permission and license from their author and amateur photographer, Manuel H. Dubón. The flora database presents and describes the flora found within the land site of the proposed sustainable resort-residential development of advanced design designated as Villa Mi Terruño. It has been expanded to cover the general flora of Culebra. FMT publishes this photographic database to offer Culebra residents, our island visitors, guests from Puerto Rico or afar, and website visitors a visual and learning experience as they enjoy the Flora of Culebra in its entire splendor.

It will hopefully enrich the visitors’ and residents’ life and leisure experience as they appreciate and better understand their subtropical environment in the Caribbean island of Culebra. The Flora Digital Database will also allow website visitors, students, and professional and amateur naturalists, to do research and enjoy a specialized photographic database of the dry subtropical Flora of Culebra with ample digital cross references.

To date, this digital database of the Flora of Culebra is the only specialized and organized photographic database of Puerto Rico flora available on the web. Except for a number of introduced exotics, the species described in the database are designated, for plant classification purposes, as subtropical Caribbean dry forest flora and form part of the larger universe of the Flora of Puerto Rico and the flora of the Puerto Rico Platform. The universe of total species identified along the eastern area of the Puerto Rico Platform, as of September 30, 2016, is of some 1,529 species, of which 550 species have been identified in the island of Culebra. There are some 20 to 25 species that have been photographed and are pending identification in the work tray. No other specialized organized HMTS web database published in Puerto Rico, other than informal sites that have some photographs or tourism general descriptions, has been found for the Flora of Puerto Rico.

As of late, FMT has found some excellent sites with general information on the Flora of Puerto Rico and excellent photographs, some that have been updated and some offering PDFs and more formal photo presentations, such as http://plantasdequebradillas.blogspot.com.

Use of photographic and other material found in the FMT Culebra Flora Digital Database

All the photographic and any other material found in the FMT Culebra Flora Digital Database, except for some minor non-proprietary photos or referenced material, is the property of its
author and/or the Mi Terruño Foundation (FMT) and it is copyrighted and protected by the laws of the United States and Puerto Rico. The author has licensed the use of the digital and printed photographic material in this database to FMT and has entrusted it with the administrative handling of special use and publishing requests. The photographic material may be used and displayed for personal and non-commercial purposes, including educational and scientific use, provided that any user places the proper copyright notices on the photo or display material (i.e., ©Manuel H. Dubón, ©M.H. Dubón, and/or ©Fundación Mi Terruño, Inc. The photographic digital or electronic material may not be commercially published electronically or in printed material or used on other public or commercial websites without first seeking and obtaining permission from the Ecological Foundation.

All requests for use of material or content on the FMT Culebra Flora and Fauna Digital Database should be addressed to FMT with a subject reference of Request for Authorization to Use Photo Database at the following email address: info@fundacionmiterruno.org. The Foundation’s contact information is published on its site. Please provide full details of the intended use, the proposed date(s) of use, frequency of use, the material to be used, that is, specifying photo(s) number(s) and flower(s) name(s), the printed or electronic material or website use being considered, and contact information including name, postal and electronic addresses, country, and the website name and URL.

The protection of the natural habitats in the VMT South Ecological Corridor and North Continuous Green Corridor, the protection during construction of significant site vegetation, and the establishment of the nursery for restoration and reforestation, are all part of creating a model sustainable development of advance planning and design that can be replicated in other parts of Culebra, Puerto Rico and the Caribbean.

Welcome to Culebra and its world of subtropical dry forest vegetation.

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FMT and the author will greatly appreciate any corrections or enhancements to its content.